REQ. NO. 1-9129

CONTRACT REPORT NO. OSQ82-00029

AN APPRAISAL OF THE PROPOSAL BY
MCINTYRE MINES FOR A
LONGWALL DEMONSTRATION PROJECT
AT THEIR GRANDE CACHE PROPERTY

FOR

CANMET

REF. 23SQ-23440-1-9129

CONTRACT SERIAL NUMBER - OSQ82-00029

JULY 1982

By

147 pp

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23 July 1982

Mr. G. Zahary
Manager - Western Operations
CANMET, Coal Research Laboratories
Department of Energy, Mines and Resources
3303 - 33rd Street N.W.
Calgary, Alberta
T2L 2A7

Dear Sir:

Re: Feasibility Study of a Proposed Mining
Demonstration Project at McIntyre Mines'
Grande Cache Property
Contract No. 0SQ82-00029

We have pleasure in submitting our final report for the above project in ten bound copies.

The report presents our appraisal of the preliminary proposals made by McIntyre Mines for a Longwall Demonstration Project at their Grande Cache property, and includes the relevant comments made during the review of the draft report.

The report contains six parts. Part 1 summarizes the report; Part 2 deals with the background, methodology and the previous longwall experience at McIntyre; Part 3 provides an assessment of the McIntyre longwall sites, and of their preliminary data which was not presented as a formal study; the summary description and requirements of the Longwall Demonstration Unit, and the suggested organization to operate and control the project will be found in Part 4. Our conclusions and recommendations will be found in Parts 5 and 6 respectively.

.../2

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We have found this project most interesting and trust that this report will be to your satisfaction. We shall be pleased to answer any questions arising from the report, and to offer our services to assist CANMET with future phases of the project.

Yours truly,

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Project Manager
Underground Mining

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C.G. Williams, P.Eng.
Vice-President,
Mining Division

IRM/dm
Encl.

THE ASSOCIATION OF
PROFESSIONAL ENGINEERS
OF ALBERTA
PERMIT NUMBER
P236
MONTREAL ENGINEERING
COMPANY LIMITED

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PART 1

SUMMARY

1.0 SUMMARY

McIntyre Mines has made a proposal to CANMET that a Longwall Demonstration Project could be undertaken at its Grande Cache property in Alberta where a suitable site is available and where staff and labour with longwall experience are also available.

CANMET awarded a contract to Montreal Engineering to carry out an appraisal of the McIntyre proposal.

Part 2 of the report deals with the background to the McIntyre Mines Operations, the terms of reference for the appraisal and describes how the project was executed. The last section of this part deals with the previous longwall operations and the lessons to be learnt from that episode.

The potential sites offered for the longwall demonstration are evaluated in Part 3, considering various pertinent factors. Mining methods and equipment tenders are examined and a determination is made of the cavability of the roof strata. Finally discussions take place on powered support specifications, secondary support specifications and the bearing capacity of the mining floor. Areas of concern were formed to the seam roof and the load berming capacity of the coal floor. Since compiling this report, the Coal Mines Research Council have carried out plate load tests at ONE location in the mine with encouraging results.

Part 4 deals with the longwall demonstration unit, setting out its objectives, outlining the basic considerations for a successful trial including benefitting from previous longwall experiences. Discussion is included on the projected capital &

operating costs. Equipment costs of up to $12 million and contributory capital costs of $8 million by McIntyre are estimated. The trial is expected to last between four and four and a half years. Part 4 concludes with brief descriptions of working organizations, critical knowledge gaps and proposals for data collection and experimental work.

The conclusions are reported in Part 5. Essentially, these are that the site offers potential for a longwall trial provided further geological and geotechnical data is obtained to confirm its suitability. A full detailed engineering and feasibility study is also required to develop the longwall face design and equipment specifications to meet the specific requirements of this site. It is concluded that the shales, mudstones and siltstones of the immediate roof are cavable with modern supports, but reservations are expressed about the caving characteristics of the sandstones which may or may not approach the seam roof. More data is required.

Similarlily, concern is expressed about the strength of the floor. Insufficient of its load carrying capacity, however, plate load tests completed by CMRC at one location in the mine suggest that the problem may not be serious. Further tests at other locations are required. Finally it is concluded that the time and place are right for a longwall demonstration to take place in a Western Canadian coal Mine.

The recommendations are submitted in Part 6. These are that a trial should take place; that mountains longwall experience is more likely to be transferrable to plains coals than vice versa; that the sites offerred by McIntyre have potential for longwall mining; that a detailed engineering and feasibility study should be completed and reviewed before proceeding to the actual trial; that the first working panel should start on the lower gradients, that projected production levels should recognize the restraints of a demonstration project, that equipment specifications and selections should be carefully reviewed before commitment to purchase; that data collection should be the responsibility of CANMET; and that a working organization be set up and that commitments to the project be given by all parties.

PART 2

INTRODUCTION

2.1 BACKGROUND

McIntyre Mines operates a large mining complex of surface and underground mines at its Smoky River Mine located adjacent to the town of Grande Cache approximately 225 miles northwest of Edmonton (Plate 2-1). The company produces, mainly for export, approximately 2.1 million tonnes of high quality coking coal of which approximately 45% comes from the underground operations.

The property contains several seams, many of which have been mined underground, however the No. 4 seam of about 20' (6.0 m) thickness has the highest quality and is considered to have the greatest mining potential.

The initial development at the mine commenced in late 1968 in the No. 2 mine - 4 seam and in the No. 5 mine - 4 seam in September 1969, using continuous miner systems to effect the development of the mines for eventual coal production using the longwall system of mining. Longwall mining commenced in late 1970 but was abandoned in mid 1971, due to geological and equipment problems. This is discussed further in Section 2.4.

Underground production since 1971 has been obtained from room and pillar systems using continuous miners and shuttle cars. This system can be highly productive in appropriate conditions, conditions which are not universally found in western Canada. Room and pillar operations are severely restricted by gradient and depth, reserves recovery is strictly limited and the method's safety record is often questioned.

The 1982 Stephenson inquiry into mine safety in Alberta recommended that the longwall mining system should be reconsidered for use in underground coal mining operations in Alberta

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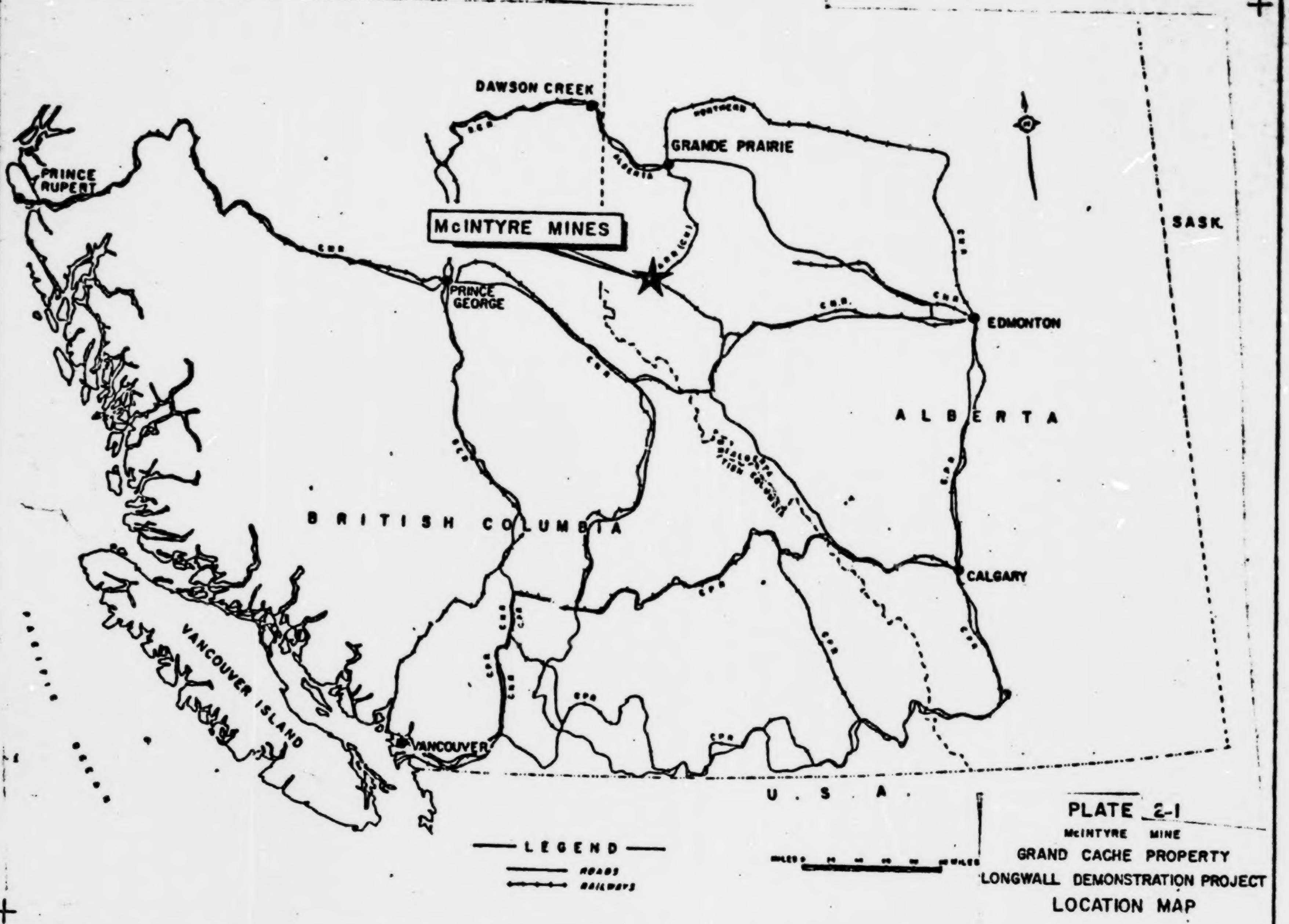


DAWSON CREEK
GRANDE PRAIRIE
PRINCE RUPERT
McINTYRE MINES
PRINCE GEORGE
EDMONTON
SASK.
ALBERTA
BRITISH COLUMBIA
CALGARY
VANCOUVER ISLAND
VANCOUVER
PACIFIC OCEAN
U. S. A.
NORTHERN
C.N.R.
C.P.R.
P.G.E.
LEGEND
ROADS
RAILWAYS
MILES

PLATE 2-1
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT
LOCATION MAP

because of its better safety record and its ability to operate in poorer ground conditions than the room and pillar system. The longwall system also offers the potential for enhancing recovery, improving productivity, and because of significant recent developments in roof support technology, it offers the ability to mine coal seams up to 4.5 m thick on gradients up to 45°.

The longwall system does have certain disadvantages when compared with the room and pillar system. The initial capital cost is high, and the system is, once installed, relatively inflexible in relation to geological changes, e.g. faults.

This inflexibility can be considerably reduced by developing the panel roadways in advance of the panel extraction and thus determining the major geological and mining conditions.

In view of the high capital requirements and the fact that no successful operations exist in western Canada - longwall is however being successfully applied in eastern Canada - McIntyre Mines approached CANMET and put forward the proposition that McIntyre, CANMET and the province of Alberta establish a demonstration project to determine the application of modern longwall mining techniques in the underground coal mining conditions in western Canada and to make the information from the operation of that demonstration unit available to the Canadian coal industry.

CANMET sought, through the Department of Supply and Service, an independent appraisal of this preliminary McIntyre proposal, and the contract for this appraisal was awarded to Montreal Engineering Company, Limited in mid May 1982.

The results of this appraisal are presented in the sections of the report which follow.

2.2 TERMS OF REFERENCE

The terms of reference are set out in the contract awarded to Montreal Engineering on May 12, 1982. The main requirements are:

(a) To review and evaluate relevant financial, engineering, operational and equipment documents of McIntyre Mines, pertaining to a proposed longwall mining demonstration at its Grande Cache property to be operated in collaboration with CANMET.

(b) To define the essential aspects of a project plan for such a longwall mining demonstration and to recommend optimal means of collaboration between CANMET and McIntyre in executing this demonstration project.

(c) The proposed demonstration is designed to generate key engineering and operations information for public use and thereby to encourage the introduction of this mining method under mountainous conditions in western Canada.

To meet with these requirements, the scope of work detailed below was given, and these have been addressed in Parts 3 and 4 of the report.

WORK STATEMENT

1. Examine potential longwall sites at Grande Cache identified by McIntyre Mines, characterize in terms of geological and geotechnical setting and evaluate their suitability for longwall mining.

2. Examine and evaluate engineering and feasibility studies developed and equipment tenders acquired by McIntyre Mines for these selected sites.

3. On the basis of data gathered in (1) and (2) determine if the massive and blocky nature of the strong roofs in the Grande Cache area will allow the controlled caving of roof necessary for a successful longwall operation.

4. If yes, determine the strength and type of supports required for controlled caving and determine if floor rocks will allow the support yield required.

5. Determine what type of secondary supports, in addition to face supports will be required under existing conditions i.e. face-end supports, buttress supports, jack supports, roadway supports, etc.

6. Summarize the recommended capital equipment, tabulating cost and availability.

7. Prepare a summary description and layout for a demonstration longwall face, with associated development, to include equipment, services, manpower, etc., as well as a description of the full cycle of operations.

8. Compile a recommended working organization and projected production levels and operating costs to be expected from the demonstration face, as well as subsequent production faces.

9. Identify any critical knowledge gaps that should be closed before a demonstration trial should be initiated.

10. Identify data to be collected and experimental work to be carried out during the trial, which will permit McIntyre, CANMET and other operators to get maximum value from the experience gained during the demonstration.

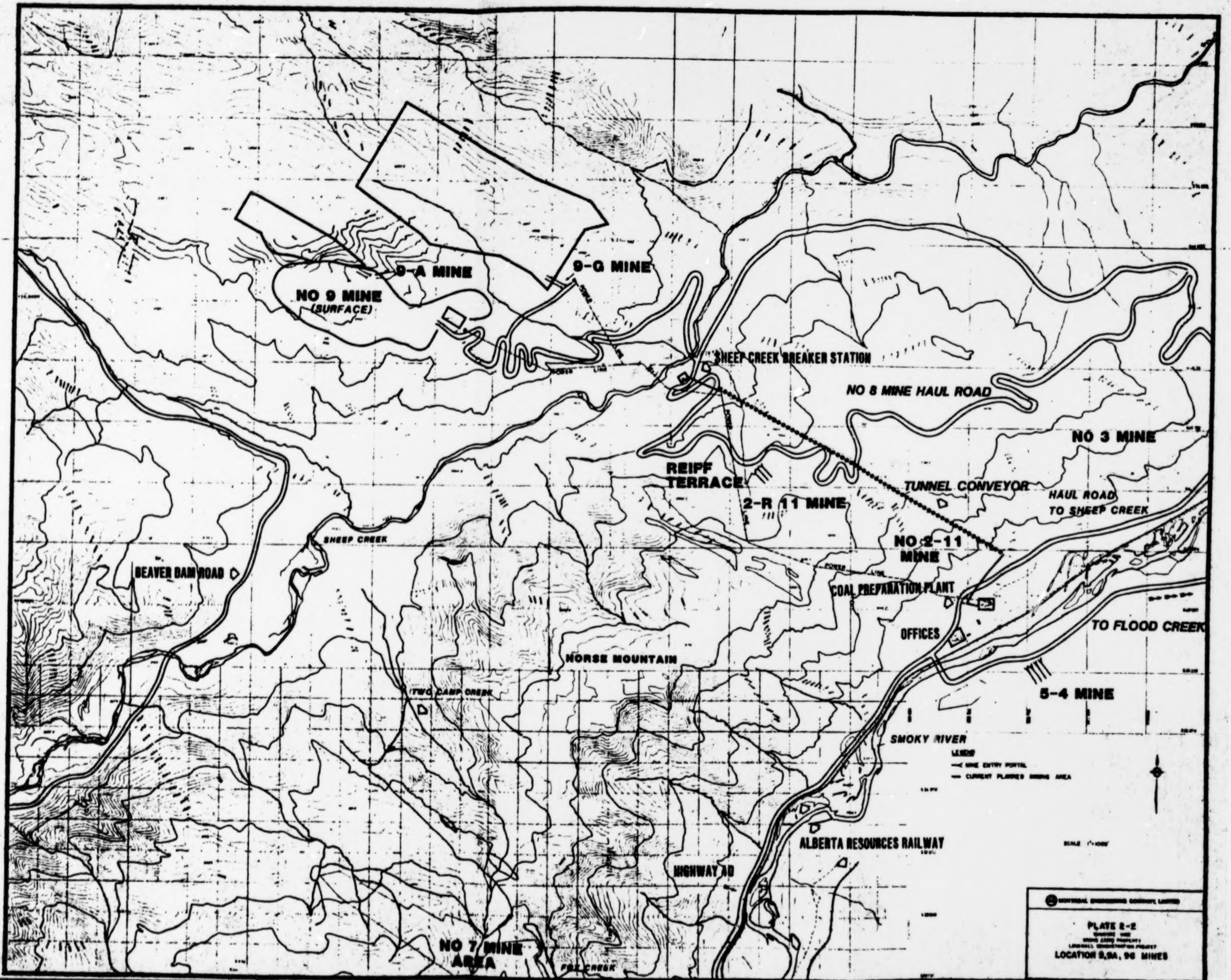
2.3 EXECUTION OF THE PROJECT

The project was executed as follows:

1. Preliminary meetings were held with CANMET and with McIntyre to review the aims of the project and to arrange for site visits and the provision of data relevant to an appraisal of the project.

2. Site visits were made to the McIntyre Mines property at Grande Cache by members of the study group.

   Underground visits were made on May 31st and June 1st 1982 to (1) the No. 9G mine which is working the No. 4 seam and which is the proposed site of the demonstration unit; (2) the No. 9A mine which is working the No. 4 seam and where depillaring and roof caving are currently being practised over areas similar to those which would apply to the long-



9-A MINE
9-G MINE
NO 9 MINE
(SURFACE)
SHEEP CREEK BREAKER STATION
NO 8 MINE HAUL ROAD
NO 3 MINE
REIFF
TERRACE
2-R 11 MINE
TUNNEL CONVEYOR
HAUL ROAD
TO SHEEP CREEK
NO 2-11
MINE
COAL PREPARATION PLANT
OFFICES
TO FLOOD CREEK
5-4 MINE
SHEEP CREEK
BEAVER DAM ROAD
HORSE MOUNTAIN
TWO CAMP CREEK
SMOKY RIVER
LEGEND
MINE ENTRY PORTAL
CURRENT PLANNED MINING AREA
ALBERTA RESOURCES RAILWAY
HIGHWAY 40
NO 7 MINE
AREA
FOX CREEK
SCALE

PLATE 2-2

LOCATION 9,9A, 9G MINES

wall faces; and (3) to the No. 9 surface mine where the full section of the stratigraphy from the floor of No. 4 seam to the surface could be seen.

The relative positions of the three mines are shown on Plate 2-2.

3. Discussions were held with the management and officials at the mine site and at the Calgary office of McIntyre Mines to obtain data necessary to permit a proper appraisal of the demonstration proposal to be made, and to clarify requirements and problem areas.

4. Various public reports pertaining to the previous longwall operations were examined and discussions held with personnel who were involved with the early longwall workings. In addition, use was made of the considerable mining data available from Montreal Engineering's in-house facilities and experience.

The study team comprised the project manager (a qualified mining engineer), a senior mining engineer, a longwall equipment specialist, a coal geologist, a geotechnical engineer and a mining cost estimator.

All McIntyre Mines plans and data are based on the Imperial system of measurement. For clarity and convenience, this report has also been written using the Imperial system, but approximate metric equivalents have also been given for comparison purposes.

2.4 PREVIOUS LONGWALL MINING OPERATIONS

2.4.1 Introduction

Any appraisal of the longwall mining demonstration proposal must try and take into account the problems which were encountered in the previous attempts in 1970 and 1971. This was some twelve years in the past and it is thus almost impossible at the present time to obtain a full picture of the events.

In attempting to reconstruct the reasons for the failure of the two longwall faces (one each in Nos. 2 and 5 mines), we have spoken to the present mine management, present and former employees of the mine who were involved with the longwall operations, perused the report of the Crump Commission of Inquiry into the loss of production at the mine and the testimony provided to the hearings, examined extracts from government mines inspectors reports and from McIntyre Mines reports.

As might be expected, the personal recollections of the individuals involved varied considerably, and were sometimes in direct contradiction with written information. However, the sole purpose of the exercise was to try and ensure that such mistakes as were made in the past are not repeated.

2.4.2 Background

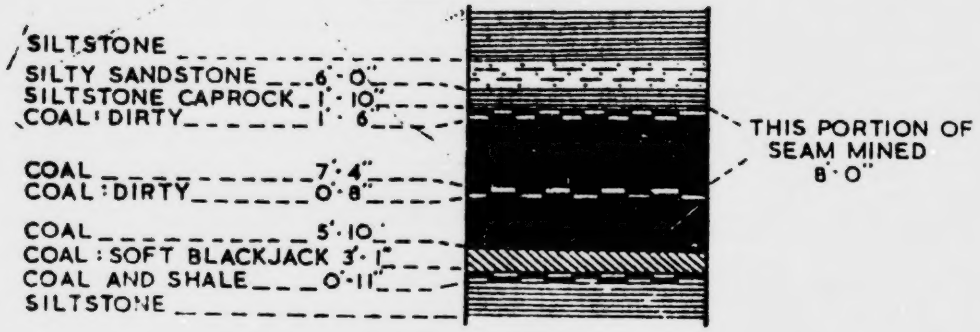
As McIntyre Porcupine Mines Ltd., McIntyre had held over 65,000 acres of leases in the Smoky River Coalfield. Prior to the commencement of mine development in late 1968, several feasibility studies had been carried out on the property. The last of these - by McIntyre staff in early 1968 - proposed that a mine of 2 million tons of clean coal capacity should be developed. The method of mining proposed was longwall retreat mining (with development by continuous miners). The reasons given for this choice when compared with mechanized room and pillar operations were:

(i) better recovery of reserves;
(ii) permitted selective mining;
(iii) ventilation was simpler and cheaper;
(iv) the floor conditions due to the expected heavy water inflows in No. 4 seam would be better. It would pose serious problems for the trackless equipment used in mechanized room and pillar systems;
(v) higher productivity was expected; and
(vi) capital cost per ton was expected to be lower.

Development of the No. 4 seam in the No. 2 mine started in late 1968 and of the No. 5 mine - 4 seam in September 1969, both using continuous miners and shuttle cars. Almost from the start, poor roof and floor conditions were quoted as the main delays to production. In No. 2 mine, floor heave was such that within the first year mine roadways were having to be dinted (excavating the floor) to regain working heights. A glance at the seam section for this mine (Plate 2-3) suggests that it could be due to the 8" (0.2 m) band of dirty coal in the immediate floor and possibly aggravated by the 3' (0.9 m) bed of "blackjack" (soft highly sheared coal) lower in the seam.

The development in both 2 and 5 mines was aimed at establishing the first longwall faces in each mine.

GENERAL SECTION OF SEAM NEAR MINE ENTRIES


SILTSTONE
SILTY SANDSTONE 6'-0"
SILTSTONE CAPROCK 1'-10"
COAL: DIRTY 1'-6"
COAL 7'-4"
COAL: DIRTY 0'-8"
COAL 5'-10"
COAL: SOFT BLACKJACK 3'-1"
COAL AND SHALE 0'-11"
SILTSTONE
THIS PORTION OF SEAM MINED 8'-0"

McINTYRE PORCUPINE MINES, LTD.
SMOKY RIVER

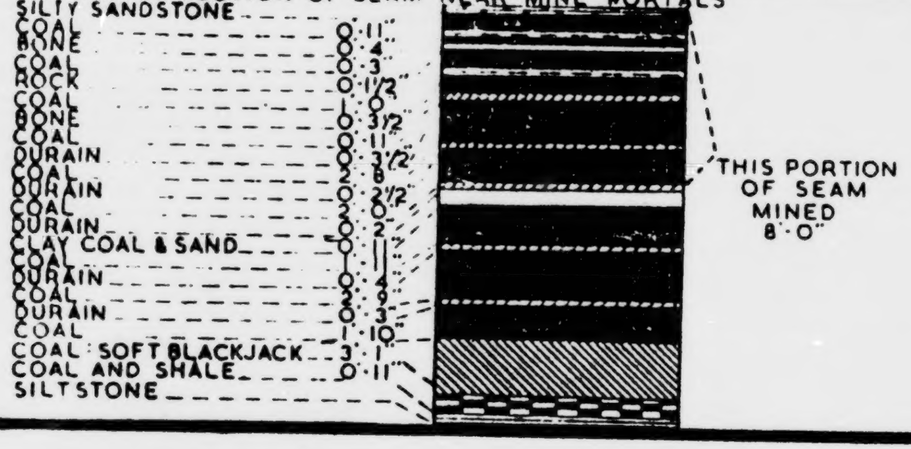
COAL DIVISION
ALBERTA

No. 2. MINE. No. 4. SEAM.
LAYOUT PLAN.

SCALE : 1. INCH. = 200. FEET.

WORKINGS IN No 11 SEAM SHOWN IN BLUE.
WORKINGS IN No 10 SEAM SHOWN IN GREEN.

GENERAL SECTION OF SEAM NEAR MINE PORTALS


SILTY SANDSTONE
COAL 0'-11"
BONE 0'-4"
COAL 0'-3"
ROCK 0'-1½"
COAL 1'-0"
BONE 0'-3½"
COAL 0'-11"
DURAIN 0'-3½"
COAL 2'-8"
DURAIN 0'-2½"
COAL 2'-0"
DURAIN 0'-2"
CLAY COAL & SAND 0'-11"
COAL 1'-11"
DURAIN 0'-4"
COAL 2'-9"
DURAIN 0'-3"
COAL 1'-10"
COAL: SOFT BLACKJACK 3'-1"
COAL AND SHALE 0'-11"
SILTSTONE
THIS PORTION OF SEAM MINED 8'-0"

McINTYRE PORCUPINE MINES LTD.
SMOKY RIVER.

COAL DIVISION
ALBERTA.

No. 5. MINE. No. 4. SEAM.
MINE No. 1765

— LOCATION —

LSD.	7.8.9.10.16.	SEC. 10.	TP. 58. R. 8. W. 6.
LSD.	3.4.5.6.7.11.12.13.14	SEC. 11.	

SCALE : 1. INCH = 200. FEET.

DRAWN BY. E.L.A.	DATE. 1st FEB 1973.	SECTION No. 1.

PLATE 2-3
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT

TRANSLAR 850-3-79

2.4.3 Longwall Operations

2.4.3.1 No. 5 Mine - 4 Seam

The first longwall face to be headed out and equipped was 503's and commenced operations in October 1970. This face was 300' (91 m) long and was equipped with FSW supports. The average gradient along the face was 5° and the average cover 1100' (335 m). The face was retreated over a distance of 260' (79 m) in a period of approximately 8 months, woefully slow by any standards.

The principal reasons for the slow progress appeared to be:

(i) lack of adequate ground control; due to

(ii) considerable problems with the design and stability of the roof supports; and

(iii) problems with the soft floor, due mainly to the 11" (0.27 m) of clay, sand and coal which virtually formed the immediate floor of the seam;

(iv) extensive delays in equipping the face thus causing deterioration in the face conditions long before mining commenced; and

(v) severe methane emission problems with the attendant ventilation problems.

(vi) depillaring operations were carried out immediately adjacent to the longwall face in an attempt to increase output. This caused a further deterioration in face conditions.

The major problems in this mine appeared to be the soft floor making it difficult to advance the supports and the problems with the supports themselves.

The supports were apparently prototypes. They proved to be unstable on gradients, canopies becoming disconnected, components getting damaged, and perhaps worst of all, the chocks tended to lower themselves automatically and in an unequal manner. Although this was traced to poor valve design, redesign never completely cured the problem.

An attempt was made in February 1971 to work at a lower face height to improve stability. A new face line was developed, but the poor conditions persisted.

One further problem compounded the issue. As production targets were not being met by the longwall face (and hence contract commitments) the pressure came to mine coal from other parts of the mine by room and pillar methods. Manpower was thus transferred from the longwall face which further reduced progress and further aggravated the conditions.

It is well known that in longwall mining, conditions improve as the rate of face advance increases. Conversely slow progress gives rise to deteriorating roof conditions and to the need to accept extra roof weight on the supports.

It is not at this time possible to attribute the longwall failure in No. 5 mine to any single cause, or to state whether it would have succeeded if either the conditions had been good or the supports reliable.

2.4.3.2 No. 2 Mine - 4 Seam

A longwall face (205's) was headed out in this mine by December 1969 but was not used because development of additional face room was not sufficiently advanced to offer continuity of production for the longwall equipment.

The first face to be equipped - 203's - commenced operations in late January 1971. The face was 430' (131 m) long, with a gradient of 5° along the face. The average cover was 550' (168 m). The face retreated a distance of 430' (131 m) in approximately 5 months, still low but considerably better than the 5 mine face. The face was equipped with Dowty 400 ton chocks. Those chocks did not suffer the same design and stability defects as the FSW supports but were similarly plagued by the supports constantly yielding.

The major problems associated with this face were:

(i) Weak floor - the immediate mining floor appeared to be 8" (0.2 m) coal and 8" (0.2 m) soft dirty coal. Floor heave was excessive.

(ii) Delays in equipping the face resulted in poor conditions on the face line at the start.

(iii) The supports yielded consistently.

(iv) Adequate roof control was never established, possibly due to a combination of floor conditions and insufficient yield resistance in the supports.

(v) As production targets were not met, men were put onto room and pillar operations to endeavour to raise output to meet contract requirements, and the longwall face was reduced to single shift per day operations, which again reduced progress and caused a further deterioration in conditions.

2.4.4 Summary

There appears to be no doubt that both management and labour were desparately anxious for the longwall system to succeed. However, there are perhaps certain lessons which should be learned from this 1970-71 episode.

We believe these are:

(1) Longwall mining requires suitable floor conditions.

(2) Equipment of proven design and reliability, and with operating experience in similar conditions must only be considered, and matched to expected conditions.

(3) Powered support load carrying capacities may need to be higher than those originally utilized in 1970.

(4) Maintenance of manning levels and commitment to the system is necessary to maintain rates of progress and thus help face conditions. The maintenance of three shift operations also assists in this respect.

(5) Depillaring operations should not be carried out adjacent to longwall operations, particularly where strata pressure effects can overlap.

(6) Proper planning and design of transportation systems for handling the heavy and cumbersome items of equipment which make up a longwall face is essential.

(7) It is also possible that absenteeism and the high labour turnover evident in 1970 and 1971 also had an unquantifiable effect on performances, especially if this involved

the skilled longwall mining and maintenance manpower. The stability and experience of the labour force should be established.

These seven points are highlighted to emphasize the need to take an integrated project approach to ensure that the design of the system is adequate and matched to the conditions; that contingency plans are made to accommodate potential problems and present a forward planning view; that sufficient trained and skilled labour and supervision are available; and that the inter-relationship between adjacent mining systems is understood.

2.5 ACKNOWLEDGEMENTS

We wish to acknowledge firstly the help and guidance we have received from Mr. George Zahary, Manager, CANMET, Western Office, who is also the scientific authority responsible for the study.

Secondly we wish to acknowledge the assistance given to us by the McIntyre Mines personnel. Mr. J.P.L. Bacharach, Vice President of Operations and Engineering, Calgary; Mr. H.D. Owen, Manager of Engineering, Calgary; Mr. T.A. Robson, Manager, Underground Mines, Grande Cache; Mr. T. Smales, Manager, Engineering, Grande Cache; Mr. J. Greenwell, Longwall Project Coordinator, Grande Cache, and their respective staffs who made their time and data freely available to the study team, often at considerable inconvenience to themselves, and thus enabled the team to obtain in the time available the best appreciation of their proposals for the Demonstration Unit.

PART 3

ASSESSMENT OF MCINTYRE MINES PROPOAL

3.1 GENERAL

The work statement required that the engineering and feasibility studies developed by McIntyre and the equipment tenders acquired by them, were to be examined and evaluated.

This requirement, in the event, turned out to be premature. As the first phase of their proposal, McIntyre had issued a discussion paper, and obtained equipment tenders, but the engineering and feasibility studies were proposed as the second phase of the project, culminating in the actual procurement, installation and operation of the Longwall Demonstration project as the third and final phase.

The discussion paper was therefore used as a basis for the examination and evaluation, supplemented by preliminary information and plans currently being assembled by McIntyre as a start for the detailed engineering and feasibility studies. These detailed studies are a necessity to ensure that the mining conditions and parameters can be fully identified and thus the mine layout, equipment, systems and manpower selected will be those most suitable for these conditions.

This should contribute significantly to the potential success of the longwall mining project and also provide the proper circumstances for the collection and dissemination of relevant data to other interested parties.

3.2 POTENTIAL SITES FOR THE DEMONSTRATION LONGWALL

3.2.1 Proposed Site

McIntyre is proposing that reserves in a specific area of No. 9G mine would be made available for the demonstration project. A plan of the No. 9G mine with the proposed longwall panels identified is presented on Plate 3-1. The first three potential panels have been delineated, each face being 550' (168 m) long and having panel lengths varying between 4000' (1200 m) and 5500' (1680 m).

The 9G mine is located to the west of Sheep Creek and is accessed by two slopes driven from the access roads for the No. 9 surface mine. These slopes expose the coal in No. 10 seam 320' (98 m) below surface and the No. 4 seam 550' (168 m) below surface.

The principal features of the proposed sites are as follows:

(a) Depth Below Surface

The depth of each panel below the surface varies considerably due to the surface topography and the anticlinal/synclinal structure of the coal surface. The ranges are given below, being in each case shallowest at the eastern end of the panel.

Longwall Panel 1 - min. 560' (170 m) max. 1080' (330 m)
2 - min. 590' (180 m) max. 850' (260 m)
3 - min. 700' (210 m) max. 1090' (332 m)

The mine roadways are driven approximately on strike and in the upper part of the seam approximately 10' (3.5 m) high and 20' (6.1 m) wide. There was no visible evidence of the effects of strata pressure in the mine, all roadways and pillars being in good condition. Plate 3-2 shows the areas visited which varied from 550' (168 m) to 700' (210 m) below the surface. Similarly, the areas visited in the adjacent 9A mine were stable, with the exception of roadways within two pillar lengths of the depillaring line. Depths below surface in the 9A mine ranged from 300' (91 m) to 800' (244 m). Plate 3-2 shows the areas visited in the 9A mine.

We therefore conclude that the developed roadways in the 9G mine will, if conditions remain as seen, be stable at least until the longwall face extraction commences. The conditions thus appear suitable for mining by the longwall retreating method, although the behaviour of pillars under the abutment pressures of longwall mining has yet to be determined.

It was noticed that where water was allowed to remain on the floor, rubber tyred traffic did churn up the floor and destroy its surface. This was more evident in No. 9A mine than in the 9G mine. The deterioration was not judged to be due to strata pressure.

(b) Geology - Seam and Immediate Strata

Plates 3-3A-D show a typical section of the No. 4 seam and the immediate strata underlying and overlaying the seam.

MONTREAL ENGINEERING COMPANY, LIMITED

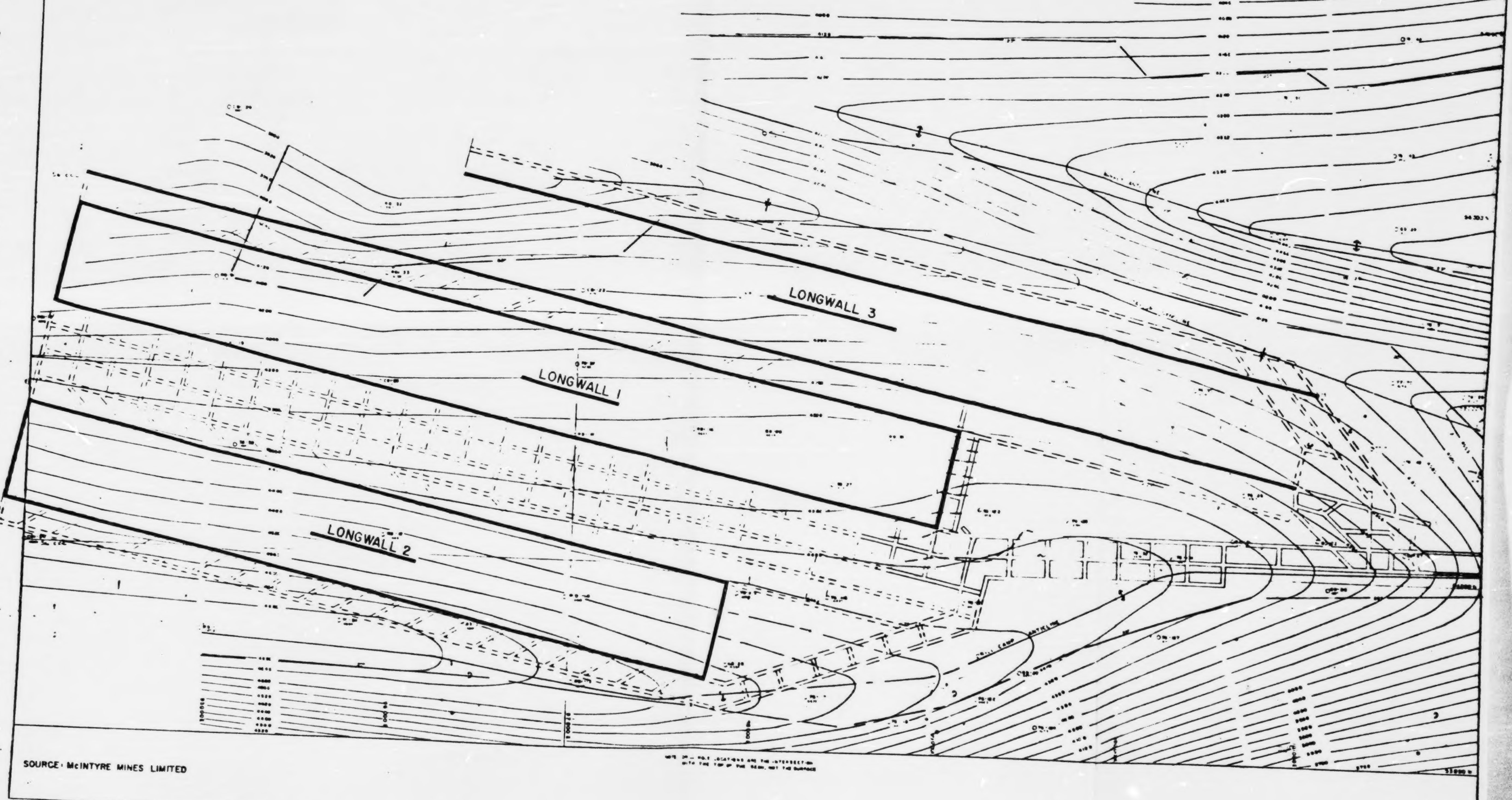
PLATE 3-1

McINTYRE MINE

GRAND CACHE PROPERTY

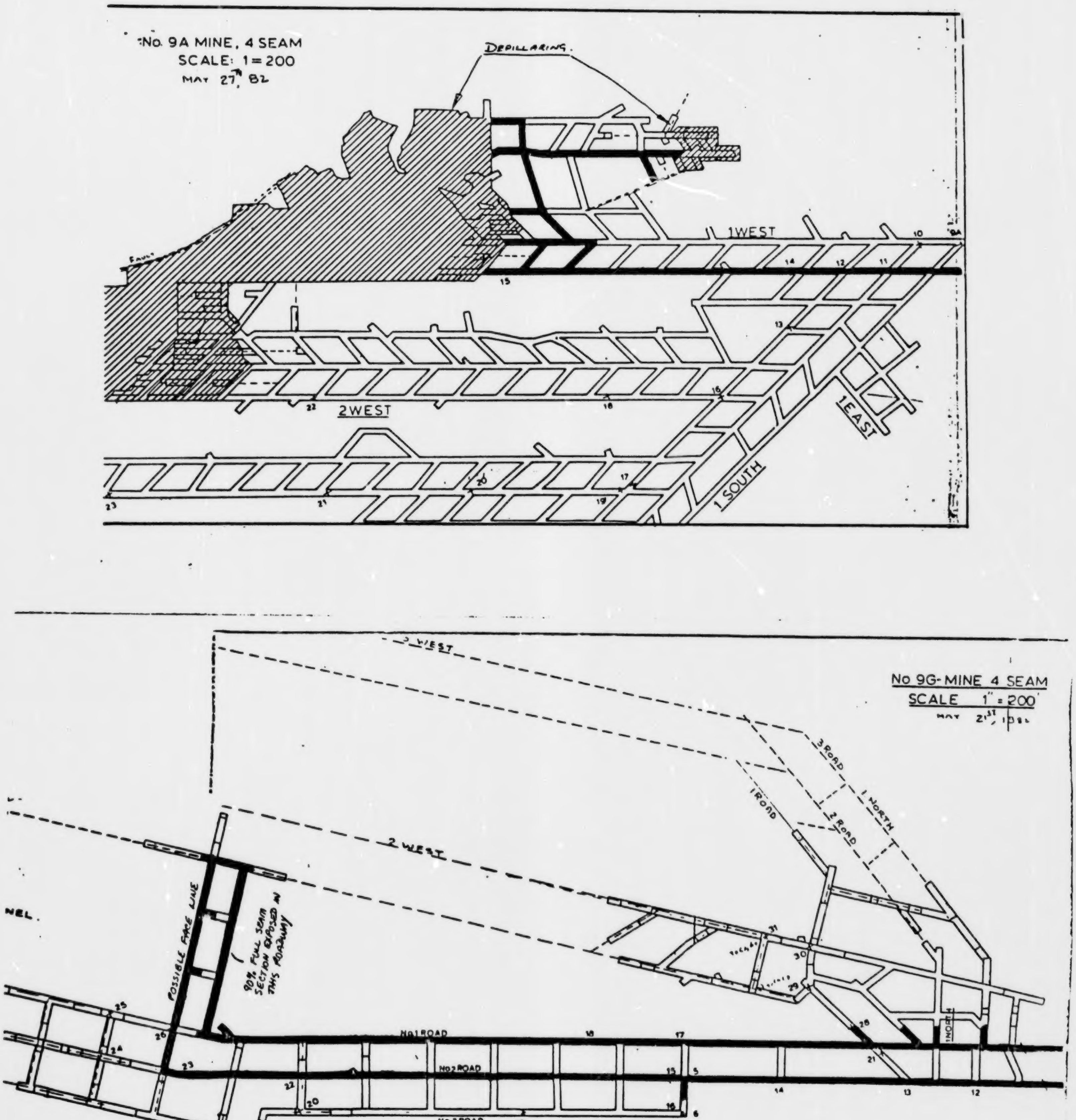
LONGWALL DEMONSTRATION PROJECT

LOCATION OF LONGWALL SITES IN Nº9G MINE



LONGWALL 3
LONGWALL 1
LONGWALL 2

SOURCE: McINTYRE MINES LIMITED

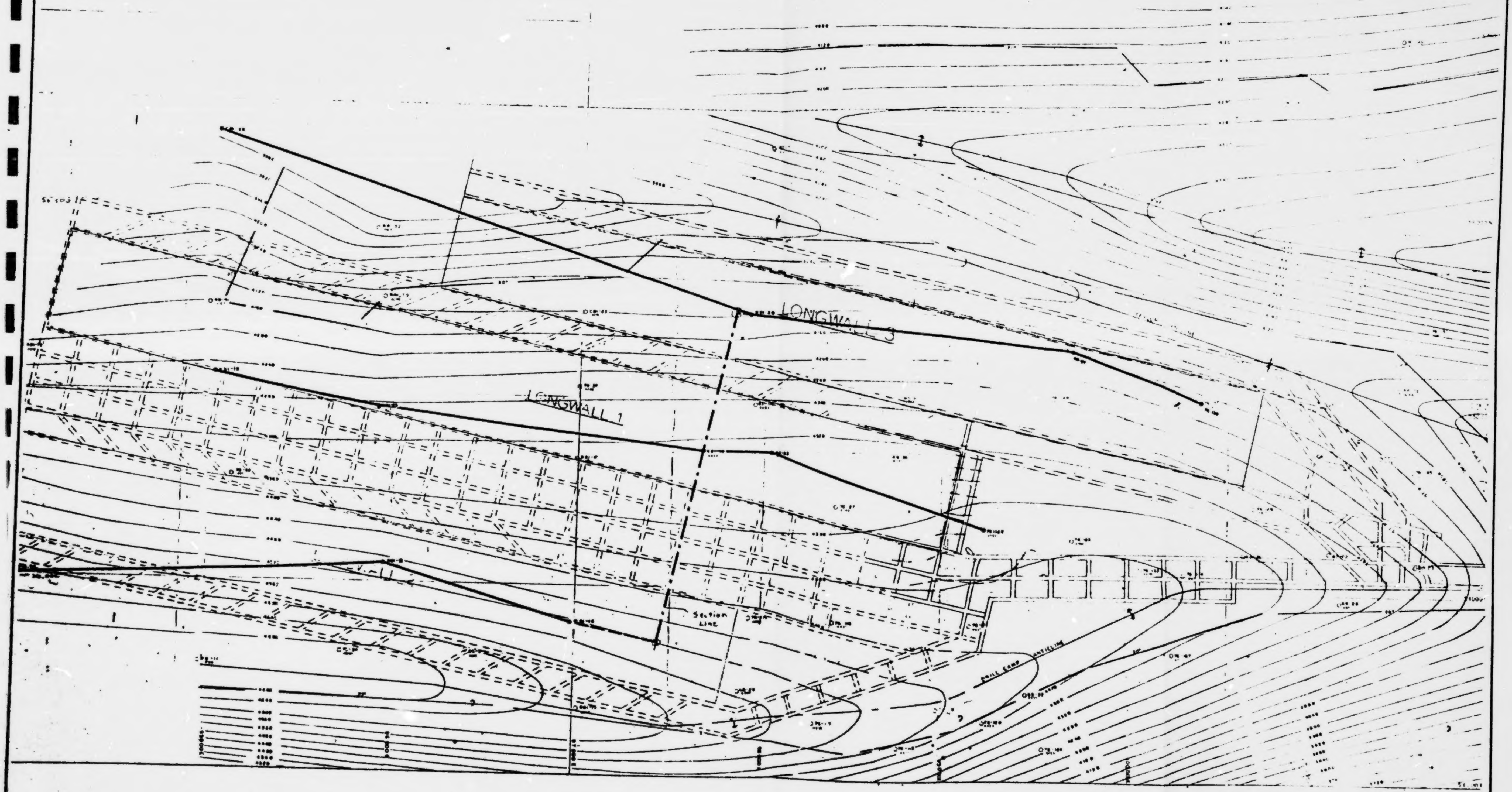

No. 9A MINE, 4 SEAM
SCALE: 1=200
MAY 27th 82
DEPILLARING.
1WEST
2WEST
1 SOUTH
1EAST
FAULT
9A
10
11
12
13
14
15
16
17
18
19
21
22
23
No 9G-MINE 4 SEAM
SCALE 1"=200'
MAY 21st, 1982
3 WEST
2 WEST
3 ROAD
2 ROAD
1 ROAD
1 NORTH
POSSIBLE FACE LINE
90% FULL SEAM SECTION EXPOSED IN THIS ROADWAY
No1 ROAD
No2 ROAD
No 3 ROAD
1WEST
1NORTH
NEL.
5
6
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
28
29
30
31

AREAS VISITED

PLATE 3-2
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT
PLAN 9A AND 9G
MINE SITE VISITS

2.5P 60%

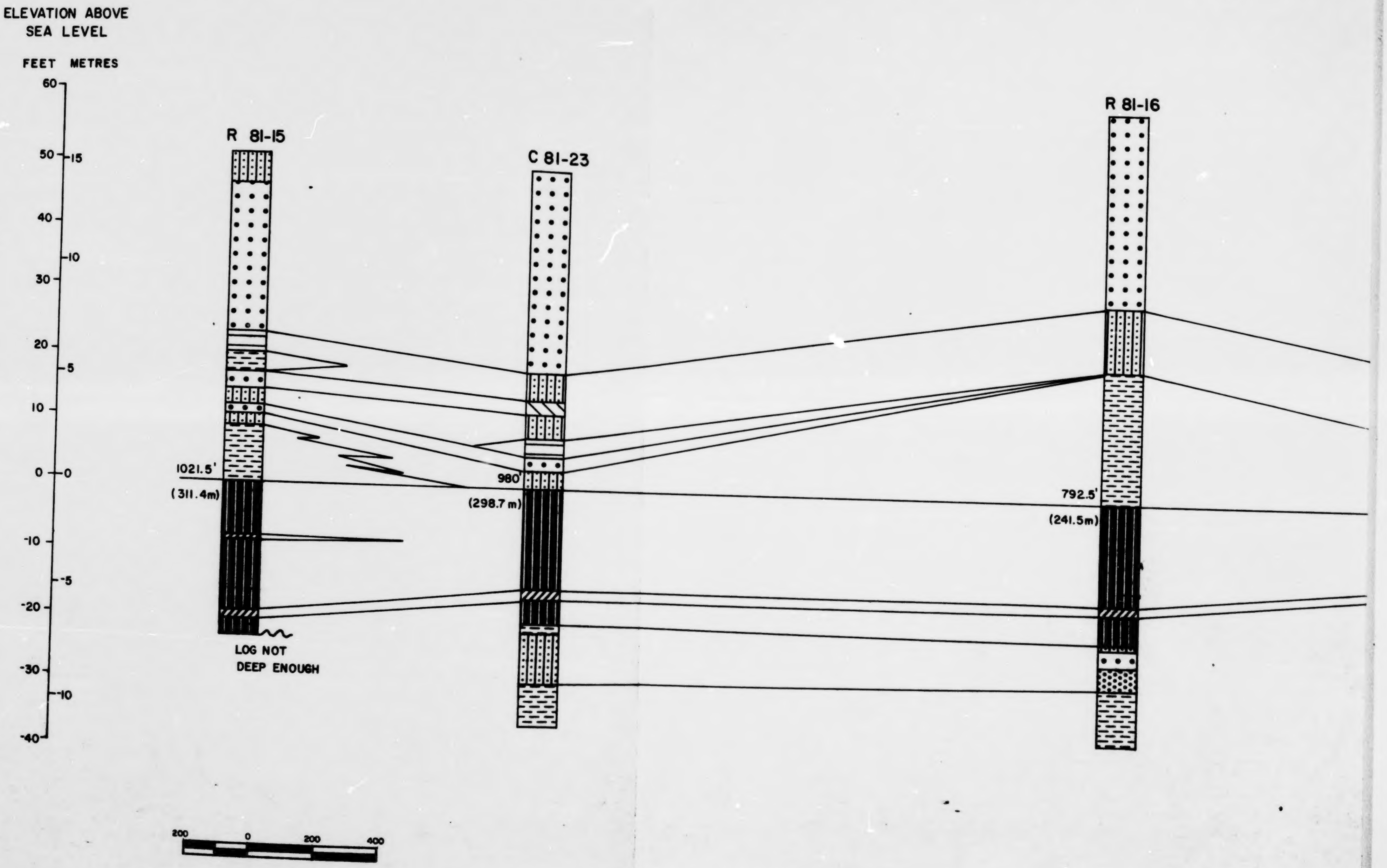
montreal engineering company, limited


LONGWALL 3
LONGWALL 1
Section Line
DRILL CAMP ANTICLINE

SOURCE: McINTYRE MINES LIMITED

PLATE 3-3
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT
SEAM & STRATA SECTIONS

MONTREAL ENGINEERING COMPANY, LIMITED


ELEVATION ABOVE SEA LEVEL
FEET METRES
60
50
40
30
20
10
0
-10
-20
-30
-40
15
10
5
0
-5
-10
R 81-15
C 81-23
R 81-16
1021.5'
(311.4m)
980'
(298.7 m)
792.5'
(241.5m)
LOG NOT DEEP ENOUGH
200
0
200
400

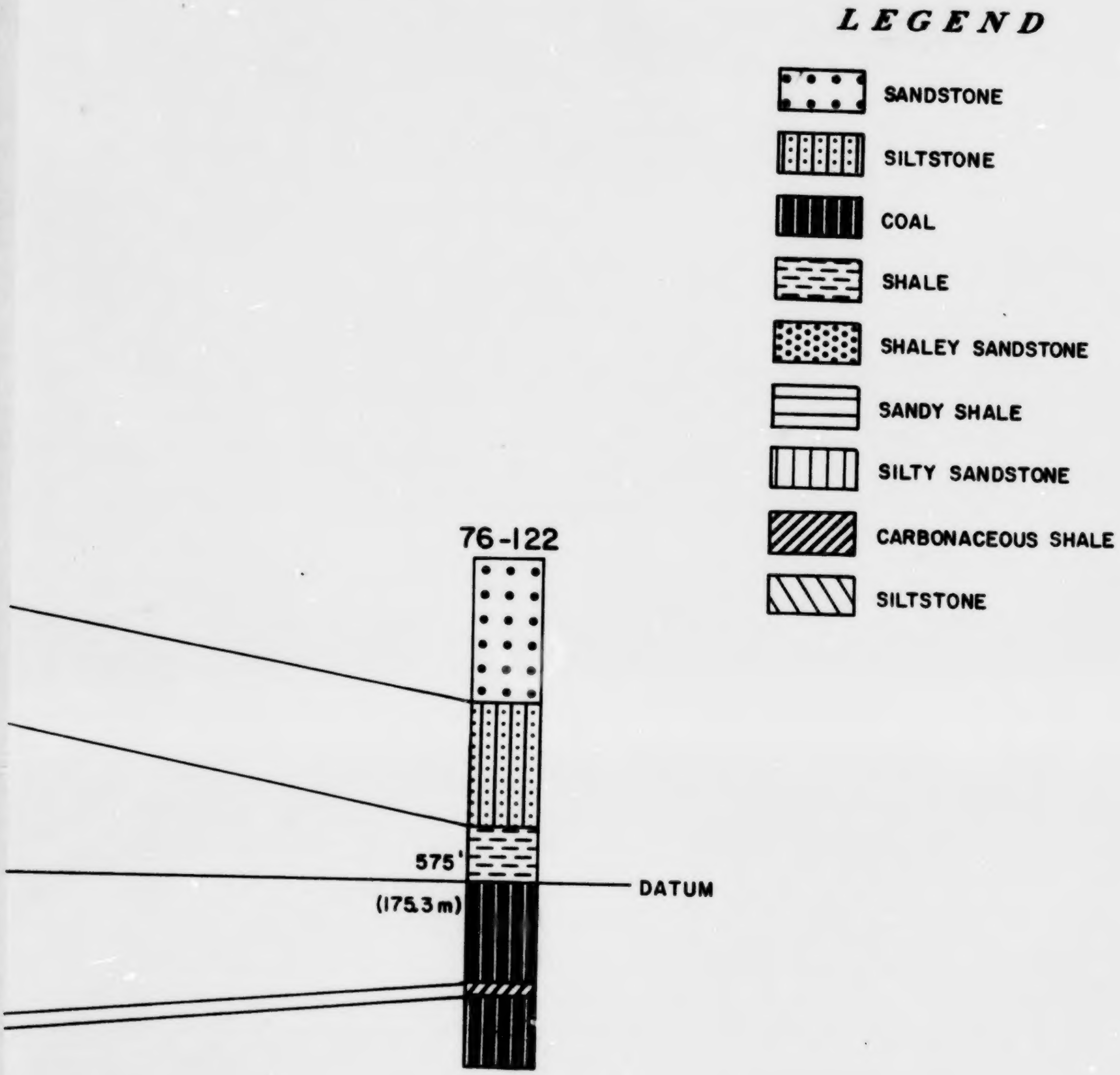
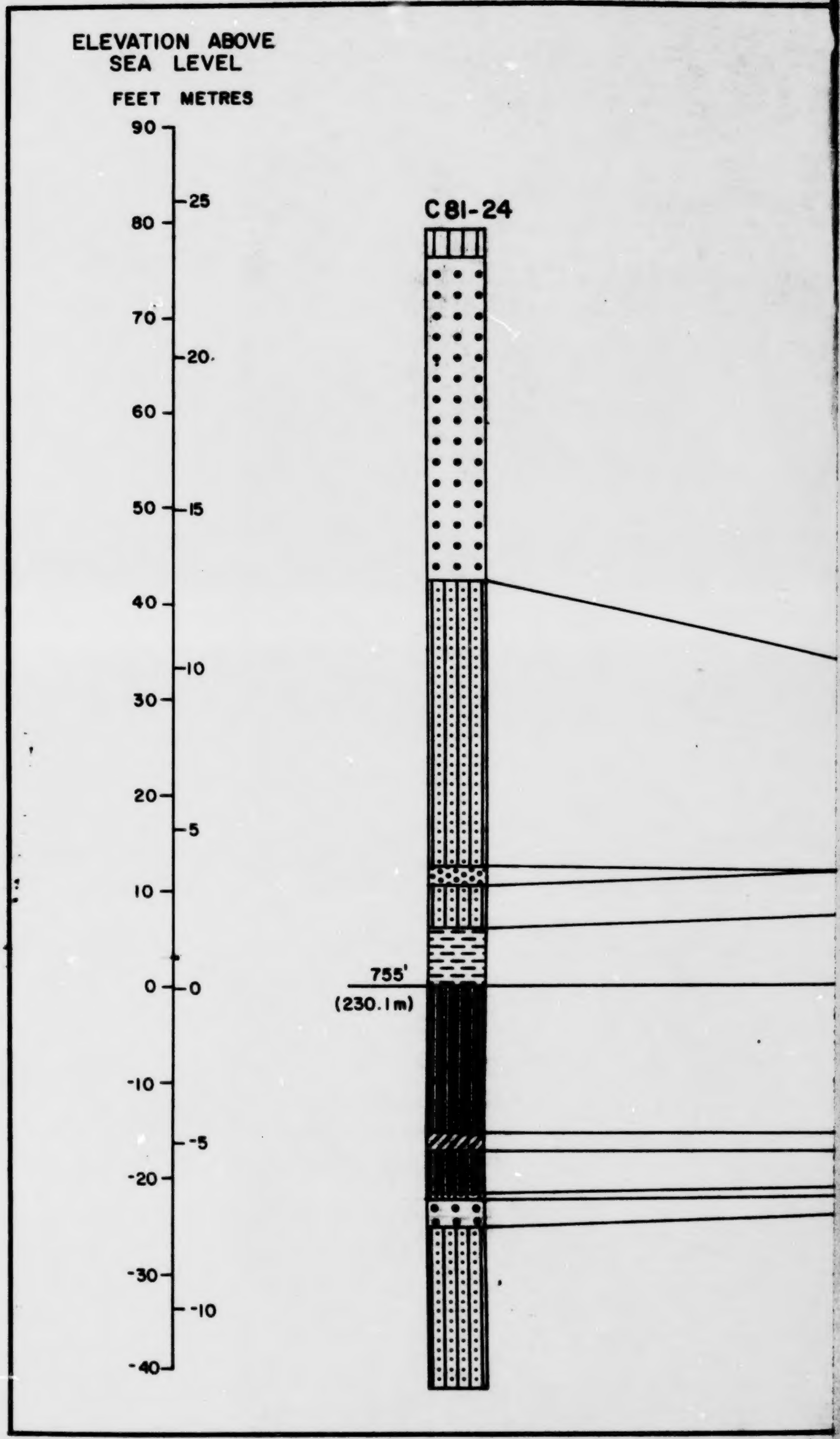

LEGEND
SANDSTONE
SILTSTONE
COAL
SHALE
SHALEY SANDSTONE
SANDY SHALE
SILTY SANDSTONE
CARBONACEOUS SHALE
SILTSTONE
76-122
575'
(175.3 m)
DATUM

PLATE 3-3A
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT

SEAM & STRATA SECTIONS
OF N°4 SEAM
LONGWALL N° 1

SECTION 1


ELEVATION ABOVE
SEA LEVEL
FEET METRES
-10
-20
-30
-40
-5
-10
C81-24
(230.1m)

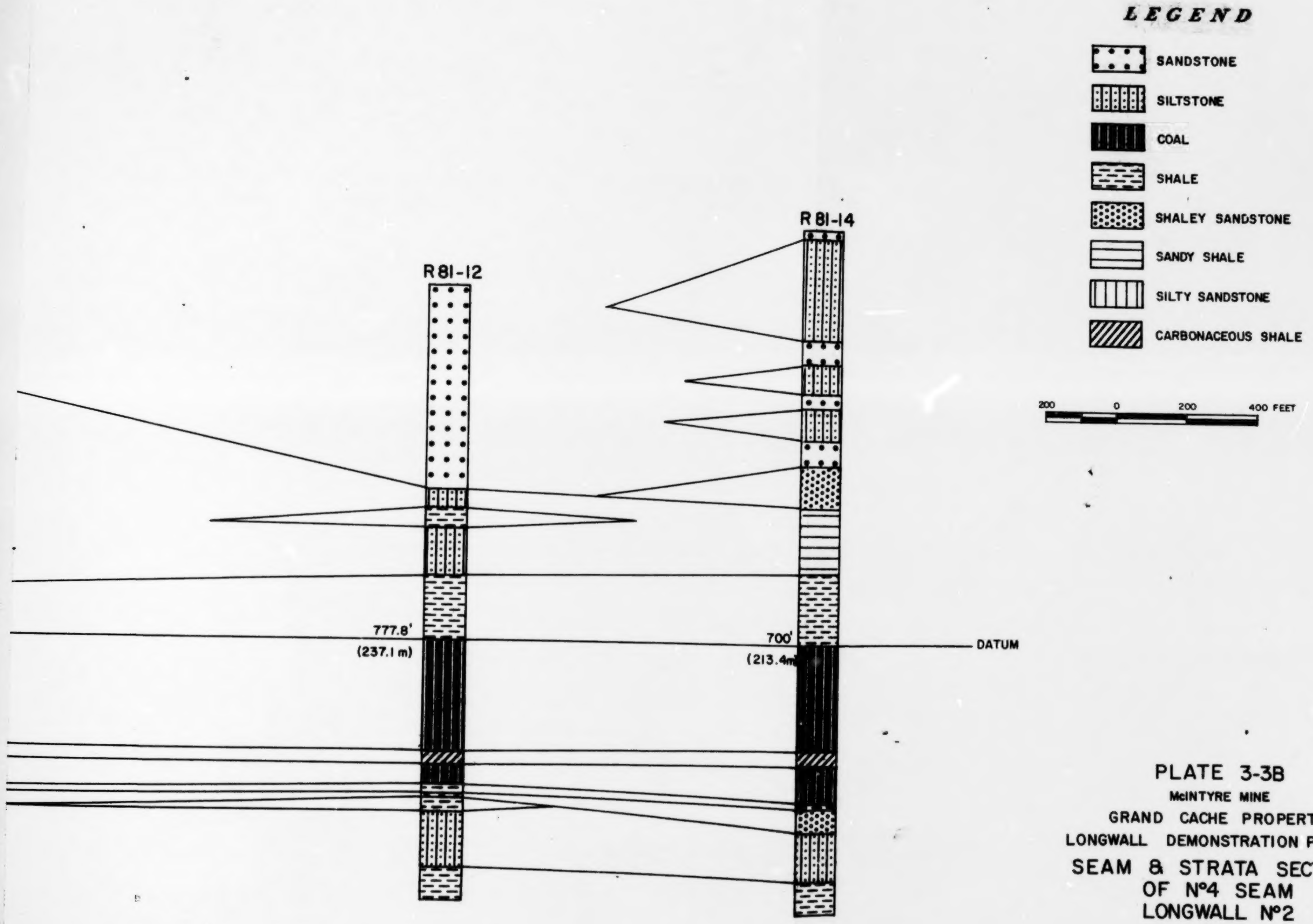
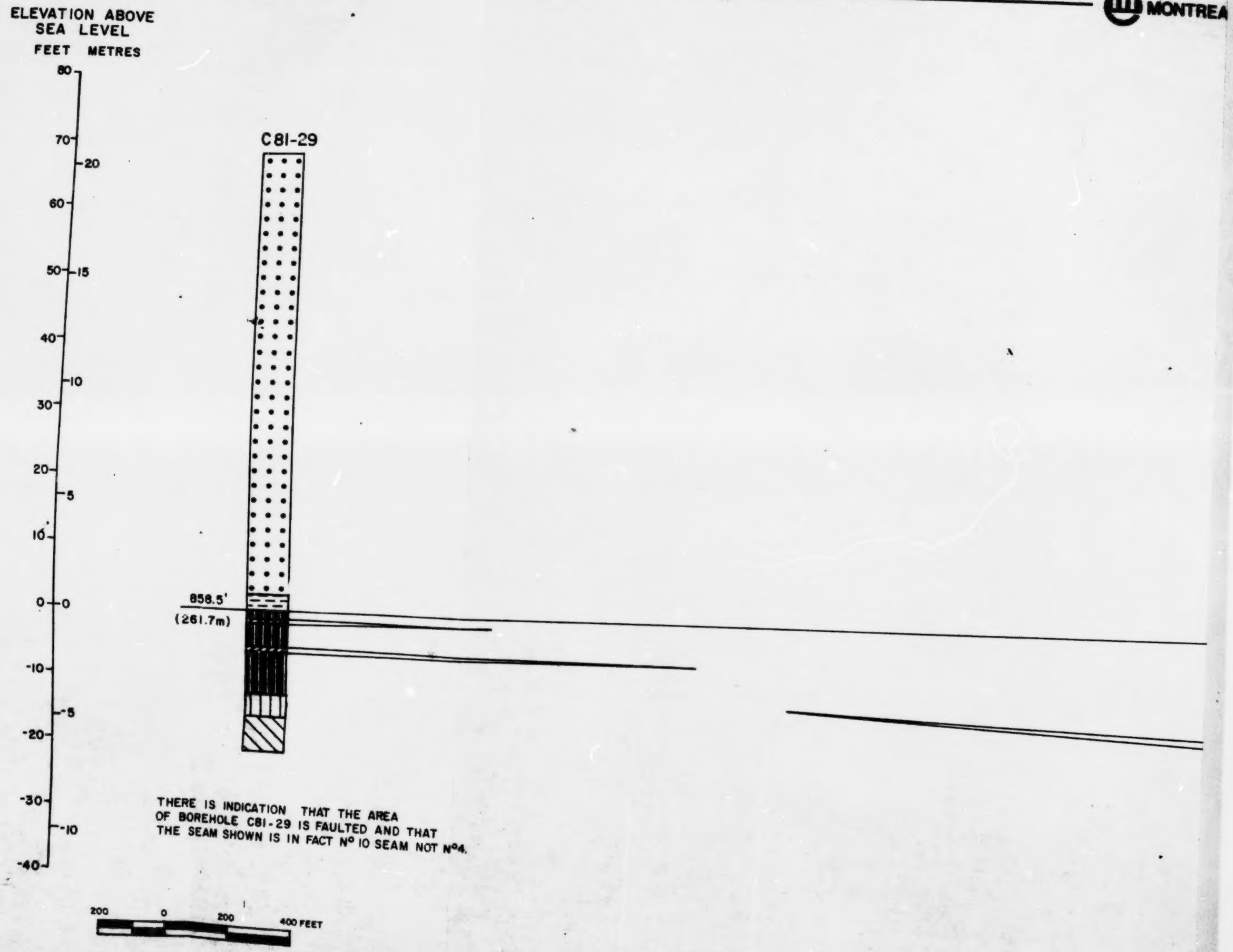

LEGEND
SANDSTONE
SILTSTONE
COAL
SHALE
SHALEY SANDSTONE
SANDY SHALE
SILTY SANDSTONE
CARBONACEOUS SHALE
200
0
200
400 FEET
R 81-12
R 81-14
777.8'
(237.1 m)
700'
(213.4m)
DATUM

PLATE 3-3B
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT
SEAM & STRATA SECTIONS
OF Nº4 SEAM
LONGWALL Nº2

MONTREA


ELEVATION ABOVE SEA LEVEL
FEET METRES
80
70
20
60
50
15
40
10
30
20
5
10
0
0
-10
-5
-20
-30
-10
-40
C81-29
858.5'
(261.7m)
200
0
200
400 FEET

THERE IS INDICATION THAT THE AREA
OF BOREHOLE C81-29 IS FAULTED AND THAT
THE SEAM SHOWN IS IN FACT Nº 10 SEAM NOT Nº4.

L ENGINEERING COMPANY, LIMITED

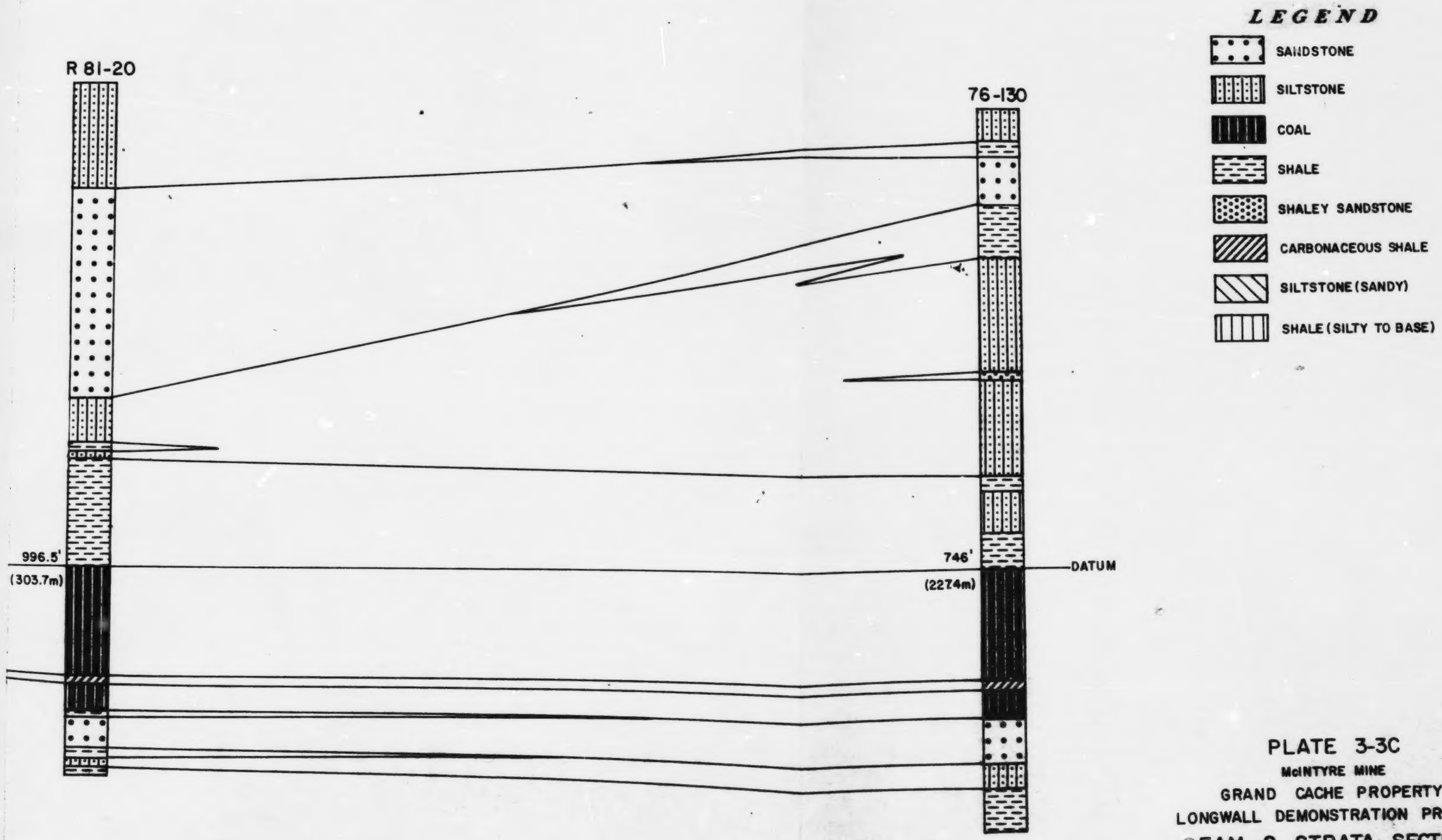
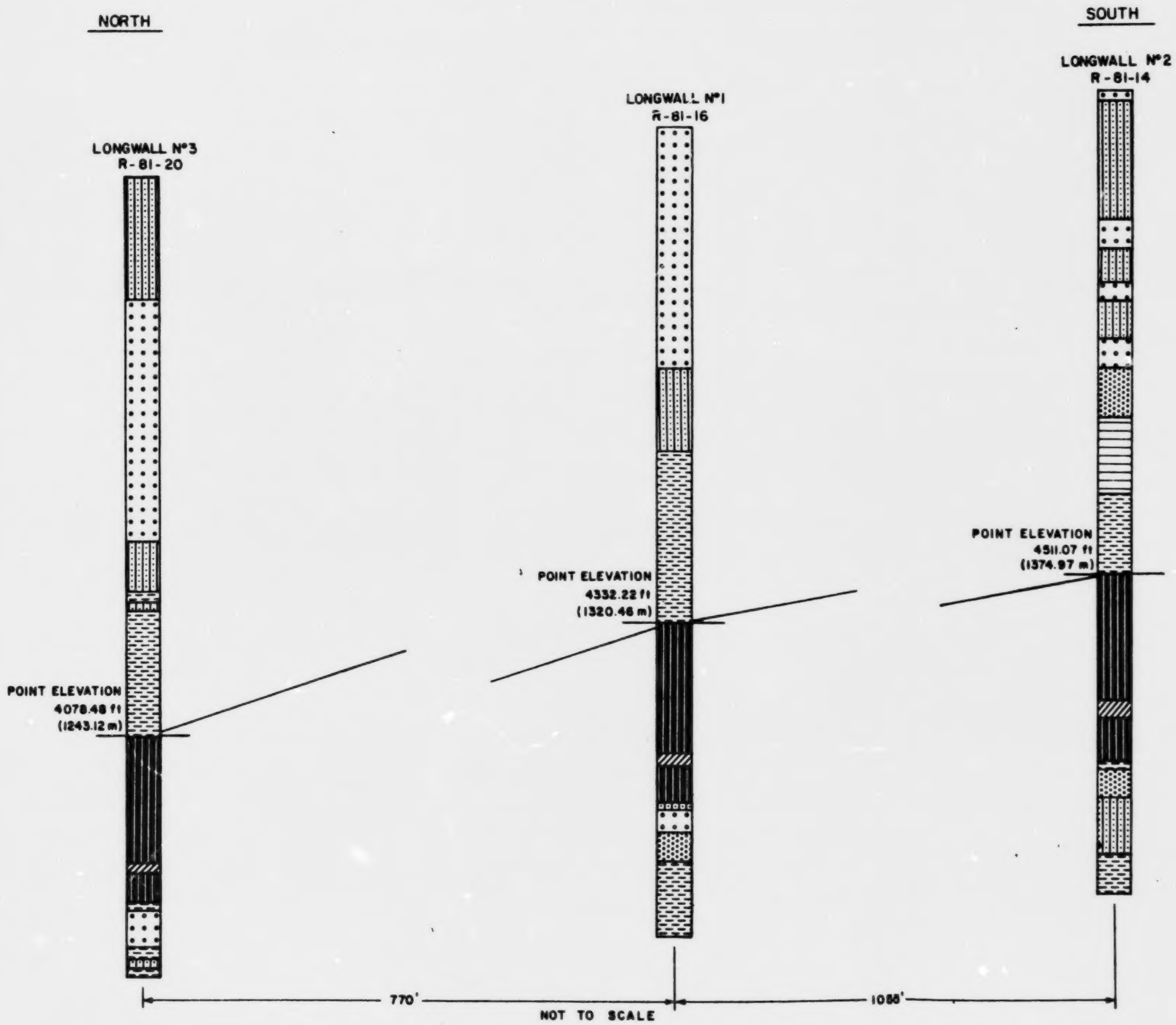
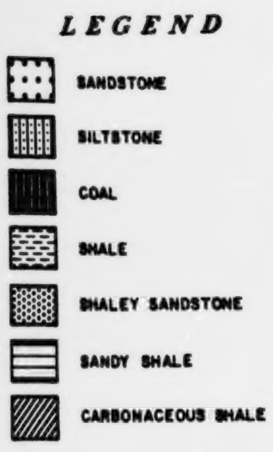

R 81-20
76-130
996.5'
(303.7m)
746'
(227.4m)
DATUM
LEGEND
SANDSTONE
SILTSTONE
COAL
SHALE
SHALEY SANDSTONE
CARBONACEOUS SHALE
SILTSTONE (SANDY)
SHALE (SILTY TO BASE)

PLATE 3-3C
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT

SEAM & STRATA SECTIONS OF No4 SEAM LONGWALL No3

MONTREAL ENGINEERING COMPANY, LIMITED


NORTH
SOUTH
LONGWALL N°3
R-81-20
LONGWALL N°1
R-81-16
LONGWALL N°2
R-81-14
POINT ELEVATION
4078.48 ft
(1243.12 m)
POINT ELEVATION
4332.22 ft
(1320.46 m)
POINT ELEVATION
4511.07 ft
(1374.97 m)
770'
1085'
NOT TO SCALE


LEGEND
SANDSTONE
SILTSTONE
COAL
SHALE
SHALEY SANDSTONE
SANDY SHALE
CARBONACEOUS SHALE

LITHOLOGIC SECTIONS HAVE A BLOWN UP
SCALE OF 1"=10' = 3.048m

PLATE 3-3D
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT
END ELEVATION

The seam floor, although not exposed in the mine, is known from drill logs to consist of a firm sandstone underlain by siltstone. This is very consistent over the mine area with the exception of an occasional siltstone lens at the base of the coal.

The No. 4 coal seam, which in the 9G mine averages between 19' and 22' thick (5.8-6.7 m) is generally of better quality in the upper section. At present, the top 10' (3.1 m) is mined during development and the lower section is only mined during depillaring operations in the room and pillar section.

The seam contains a number of sheared coal zones, especially in the lower half. Plate 3-4 shows the section of the seam as logged in borehole C81-23 which intersects Longwall Panel No. 1 approximately 3200' (975 m) from the present face heading. Examination of the lower section of the seam exposed in the heading adjacent to the proposed face line (Plate 3-1) showed similar zones of sheared coal below the mine floor, though not as extensive as the 81-23 borehole log. This sheared coal does represent an area of concern and is discussed further in Section 3.6.

The immediate roof above the seam is a firm grey silty shale which is competent enough to provide safe and adequate roadway support when held with 6' (1.8 m) mechanical rock bolts on 4' (1.2 m) centres and with mesh.

The silty shale varies from 5' (1.5 m) to 8' (2.4 m) in thickness. Above the shale is a siltstone sequence which varies in thickness from 9' (3 m) to 16' (4.9 m). This is overlain by sandstones and silty sandstones of varying thicknesses.

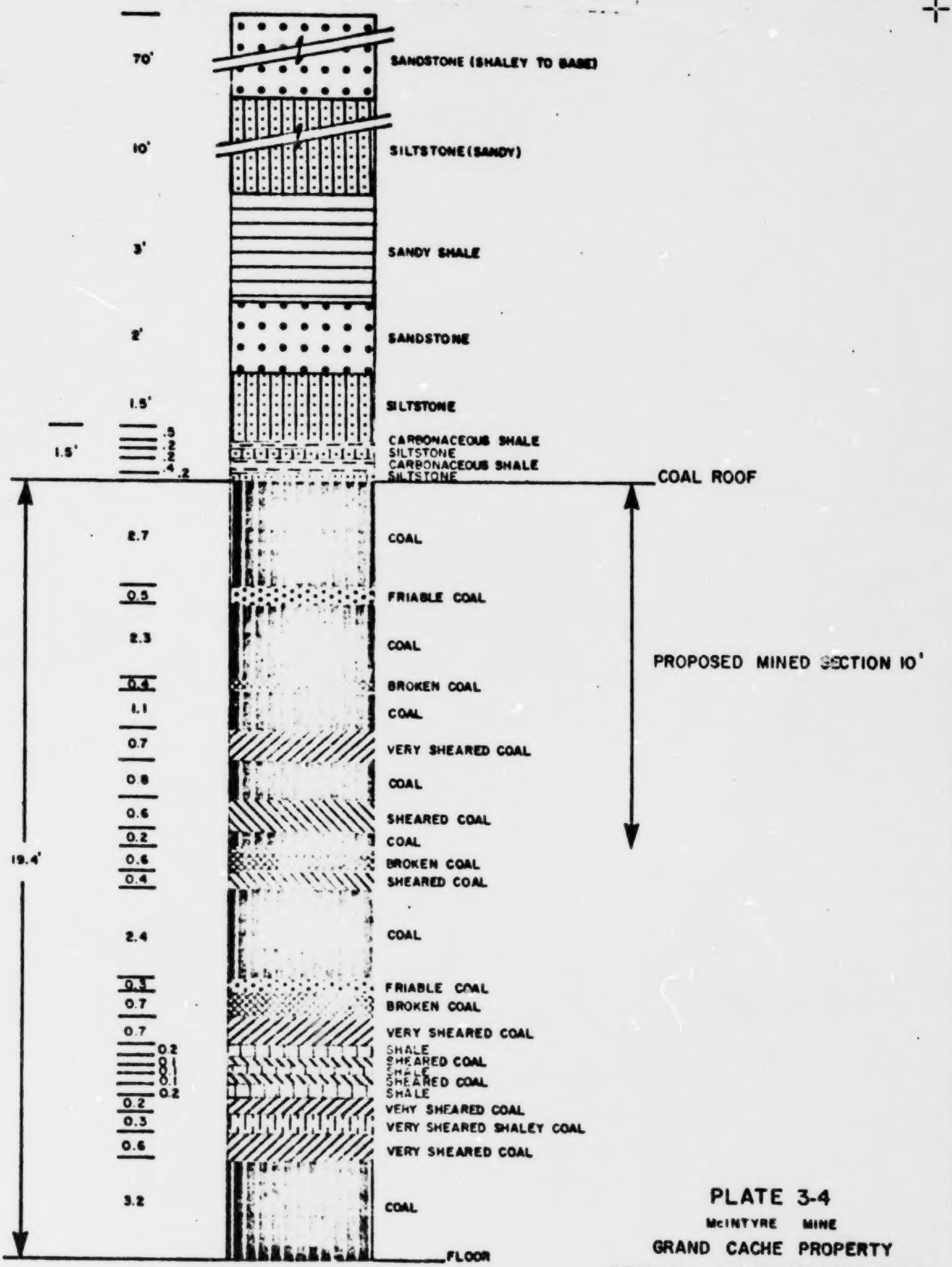

70'
SANDSTONE (SHALEY TO BASE)
10'
SILTSTONE (SANDY)
3'
SANDY SHALE
2'
SANDSTONE
1.5'
SILTSTONE
1.5'
.5
CARBONACEOUS SHALE
.2
SILTSTONE
.2
CARBONACEOUS SHALE
.4
.2
SILTSTONE
COAL ROOF
2.7
COAL
0.5
FRIABLE COAL
2.3
COAL
PROPOSED MINED SECTION 10'
0.4
BROKEN COAL
1.1
COAL
0.7
VERY SHEARED COAL
0.8
COAL
0.6
SHEARED COAL
0.2
COAL
19.4'
0.6
BROKEN COAL
0.4
SHEARED COAL
2.4
COAL
0.3
FRIABLE COAL
0.7
BROKEN COAL
0.7
VERY SHEARED COAL
0.2
SHALE
0.1
SHEARED COAL
0.1
SHALE
0.1
SHEARED COAL
0.2
SHALE
0.2
VERY SHEARED COAL
0.3
VERY SHEARED SHALEY COAL
0.6
VERY SHEARED COAL
3.2
COAL
FLOOR

PLATE 3-4

McINTYRE MINE

GRAND CACHE PROPERTY

LONGWALL DEMONSTRATION PROJECT

9G 4 SEAM

BOREHOLE C81-23

COAL SECTION

Randomly spaced groups of fractures with spacings within the groups of 1' (0.3 m) to 3' (0.9 m) were evident in the immediate seam roof in both 9G and 9A mines, these fractures being generally at 90° to the strike. Examination of the stratigraphy exposed in the highwall of the No. 9 surface mine indicated frequent vertical joints both along and at right angles to the strike. These joints were continuous through the shale, siltstone and sandstone beds. Faulting does not appear to be a major problem.

The question of the cavability of these rocks under longwall mining conditions is dealt with in Section 3.4.

(c) Gradients

In general, the area designated for the longwall demonstration lies on the limb of an anticlinal/synclinal structure between the Drill Camp anticline and the Taylor Syncline, both of which trend roughly on a northwest-southeast line. The whole structure is also plunging gently in the southeasterly section.

Plate 3-5 gives the top of No. 4 seam contours for the 9G mine. The location of the three designated longwall panels is shown, and the gradients across the face are given at 1000' (328 m) intervals within each panel.

It will be seen that for No. 1 panel, the gradient along the face ranges from 4° at the eastern end through a gradual change to 16°/17° at the western end.

For No. 2 panel, the change from west to east is almost negligible, commencing at 17° and flattening slightly to 14°. This panel runs approximately 300' (91 m) from the Drill Camp Anticline. For No. 3 panel, the eastern end starts at 15° and is consistently in the 16°-18° range for approximately 5000' (1520 m). If the panel is continued to the same western limit as panel #1, gradient steepens to 29° and also reverses direction as the Taylor syncline moves into and out of the panel, the gradient finally flattening slightly to 20° at the western end.

Along the line of advance, the gradients are:

No. 1 Panel - average dip - east to west of 3°
No. 2 Panel - average dip - east to west of 1°
No. 3 Panel - the gradient from east to west is variable -

	0 - 1500' (460 m)	1° rise
	1500' (460 m) - 5000' (1520 m)	5° dip
if mined	5000' (1520 m) - 6000' (1830 m)	3° rise (estimated)
	6000' (1830 m) - 6500' (1980 m)	11° dip (estimated)

This panel runs approximately 200' (61 m) from the Taylor syncline until the latter enters the face area as indicated above.

The gradients expected in the longwall panel zones are well within the operating capabilities of modern longwall equipment. Judged purely from the standpoint of gradients, Panel 1 is the obvious starter, working from the east to west, commencing on relatively flat gradients and gradually steepening. The panel is also favourably loca-

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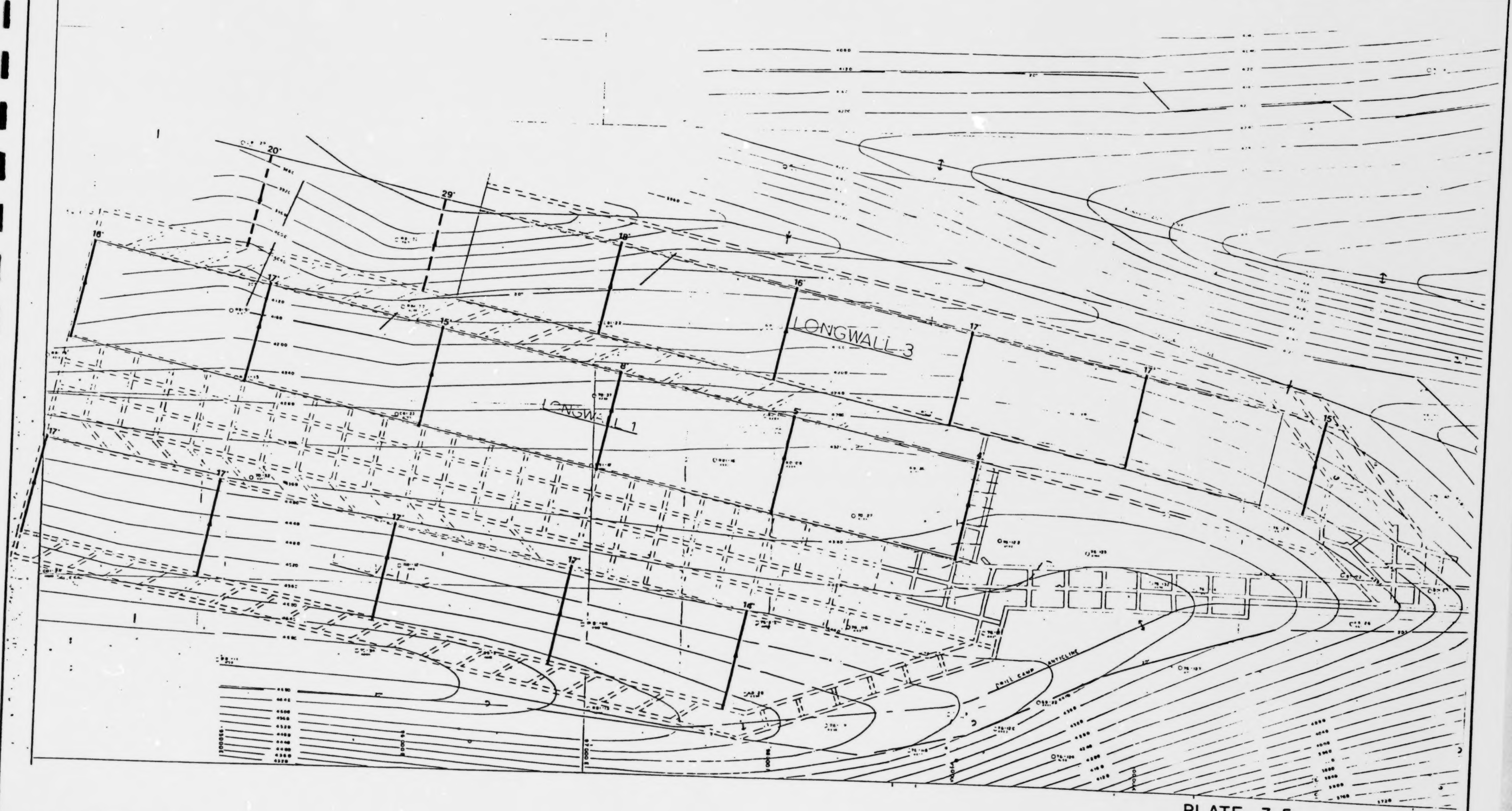


20'
29'
18'
18'
17'
16'
15'
17'
17'
15'
17'
17'
17'
17'
16'
LONGWALL 3
LONGWALL 1
CAMP ANTICLINE

SOURCE: McINTYRE MINES LIMITED

PLATE 3-5
McINTYRE MINE
GRAND CACHE PROPERTY
LONGWALL DEMONSTRATION PROJECT

ted midway between the axes of the anticline and syncline and therefore less likely to be subject to severe stress.

Panel 2 presents the best choice for the second working unit as its crossface gradient is virtually constant and equal to the maximum experienced on panel 1. The panel parallels and runs close to the Drill Camp anticline which should also provide valuable experience.

Panel 3 presents the opportunity, IF REQUIRED, to experience (eventually) steeper face gradients, undulating gradients in line of advance, and the effects of the presence of a syncline in the face line.

One less attractive alternative could be to seek an initial panel with consistent gradient conditions. Panel 2 meets this criteria but it would mean starting up a brand new system on a 14°/17° gradient. On the whole we prefer Panel 1 as the starting point.

In general, therefore, we conclude on the basis of the evidence available, that the gradients present do not preclude the operation of longwall mining systems, provided that equipment is properly specified for, and manpower is experienced in the steep seam operations.

(d) Adjacent Workings

The area proposed for the longwall demonstration unit is, as can be seen in Plate 2-2, in a virgin area of coal. The nearest workings (caved) are some 5000' (1520 m) away to the west on another anticline/syncline limb in the 9A mine.

Panel 1 would therefore be mined through virgin coal, Panel 2 would be mined with an 'adjacent' caved area down dip, and Panel 3 mined with an adjacent caved area to the rise.

We firmly believe that the existing mine workings should have no effect on the proposed longwall mining area in the 9G mine.

(e) Environmental Conditions

(i) Water Inflows

There was evidence of water inflows particularly in the No. 10 seam in the 9G mine and also in the No. 4 seam. The total flow into the 9A mine was 150 gpm (11 l/s), the water originating from both development and depillared areas. The total inflow into the 9G mine was 60 g/m (4.5 l/s), most of which (80%) originated from the No. 10 seam entry some 240' (73 m) above the No. 4 seam.

Water is apparently present in very small quantities during initial development, but dries up with the passage of time.

Since there are sheared coal and also shale zones in the coal below the present mine floor, which will probably deteriorate in the presence of water, more data should be obtained about the sources and quantities of water and its effects on the mining floor. This is dealt with in more detail in Sections 4.6 and 4.7.

(ii) Methane Emission

The quantities of methane measured in the general body of the mine are extremely small and have, we understand, only exceeded 0.1% once. Methane emissions usually increase as workings become deeper. The depth of the 9G workings will increase from the present 500' (152 m) to about 1100' (335 m). The mine does not appear to be 'gassy' and methane emission should not be a major problem for longwall mining. However more detailed information is required before a proper judgment can be made.

(iii) Ventilation

The introduction of a longwall mining system usually requires a larger volume of air than for a room and pillar system. The mine roadways are generally of good cross-section - 200 sq. ft. (18 m^2) - and should be able to pass the extra volumes. Provision is made at the fan drift for the fan capacity to be increased to 300,000 cfm (140 m^3/s).

The present ventilation system was designed on the NCB computer in the U.K. and we understand that the system for the longwall will be similarly developed during the detailed feasibility study.

(iv) Airborne Dust

The No. 4 seam is classed as a competent coal in the upper beds and soft friable coal in the lower beds.

It was not possible to see coal being cut during the site visits due to available time. The mined coal section appears competent. Dust production on a longwall face could therefore be a problem especially if high air volumes are required. Face air velocities are usually limited to a maximum of 700 fpm (3.5 m/s). Dust control will have to form an important part of the longwall design.

3.2.2 Suitability of the Proposed Sites

Any demonstration project for a 'new' system should preferably be undertaken in ideal conditions. For a longwall mining demonstration, this should be in flatter seam conditions. In western Canada, these conditions are to be found more commonly in the plains coalfields. However, at the present time, no underground mines are operating in the plains coalfields, nor are any expected to be developed to the stage where a demonstration project could be undertaken within the immediate future.

It is desirable that a demonstration project should, in any case, be undertaken in both plains and mountain/ foothills coals since many mining conditions are dissimilar.

However, experiences with a longwall system in mountain coals are more likely to be transferrable to plains coals than vice versa.

The proposal by McIntyre Mines represents an opportunity to test the longwall mining system under controlled and monitored conditions in mountains/foothills coal fields, and with a system and equipment carefully designed to meet the expected mining conditions.

The proposed sites appear to be physically suitable for the project, provided more data can be collected and assessed with respect to the load bearing characteristics of the mining floor (see Section 3.6) and the characteristics of the sandstones above the seam.

The three panels indicated on Plate 3-1 offer a range of physical conditions seldom found in any one mining area.

Panel 1, if mined from east to west, offers a reasonable face gradient (4°) at the start, steepening to 17° at the end, and a panel in undisturbed ground. Panel 2 offers virtually constant steep face gradients (17°) equal to the maximum mined in Panel 1, but with an anticline axis adjacent on one side and caved waste reasonably adjacent on the other, i.e. constant conditions.

Panel 3, east to west offers a 16° start and if mined to the same western limit as Panel 1, gradually steepens to 29° and includes a reversal of gradient on the face. In addition it offers a varying rising and dipping gradient along the line of face advance.

These three panels thus offer an interesting range of conditions for a longwall demonstration unit in mountain coal conditions. The first two panels represent a potential life for the demonstration project of between three and four years. It will, however, be necessary for the engineering and feasibility study to examine all the factors affecting the sequence and direction of working.

3.3 MINING METHODS AND EQUIPMENT TENDERS

3.3.1 General

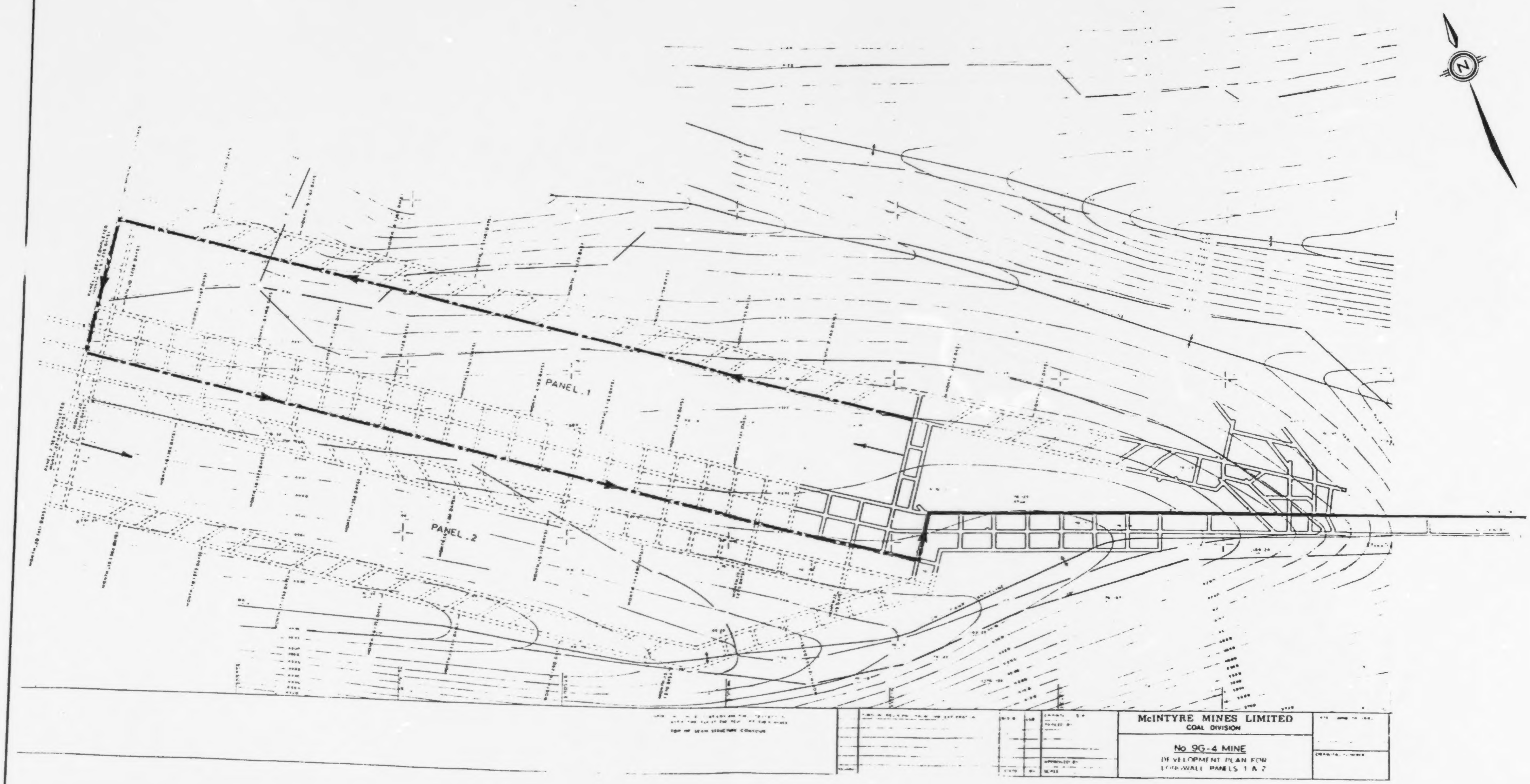
The terms of reference require an evaluation to be made of the proposed mining methods and of the equipment tenders received from potential suppliers. Whilst McIntyre Mines have obtained tenders from three potential suppliers, no firm mining method has yet been proposed since this is to be decided as part of the detailed feasibility study. However, during discussions with McIntyre management, certain concepts were identified and comment on these is given below.

3.3.2 Mining Methods

(1) Panel Layout

McIntyre propose to drive the roadways for panel no. 1 - two on the north side and three (ultimately five) on the south side of the panel (Plate 3-5) - to the panel boundary and thus will provide advance knowledge of the geology and also enable additional test data to be collected regarding roof and floor strata.

Once this drivage has been completed, two possibilities exist. Firstly to retreat the longwall face inbye (east to west) along the prepared roadways and allow the main and tailgate roadways to collapse, thus simplifying the face end support problems and reduce the need for roadway maintenance and repair. This system would require the gate conveyors to transport the coal to the west end of the panel and before returning down the five entry block to the mine access slopes (Plate 3-6).


N
PANEL. 1
PANEL. 2
TOP OF SEAM STRUCTURE CONTOUR
McINTYRE MINES LIMITED
COAL DIVISION
No 9G-4 MINE
DEVELOPMENT PLAN FOR
LONGWALL PANELS 1 & 2

SOURCE: McINTYRE MINES LIMITED

PLATE 3-6

McINTYRE MINE

GRAND CACHE PROPERTY

LONGWALL DEMONSTRATION PROJECT

CONVEYOR ROUTING PANEL 1

The alternative is to start the longwall face at the west end and retreat the face outbye (west to east) along the prepared roadways, the coal being conveyed directly out of the mine.

The main advantages of the first method are that the longwall face starts on the flatter gradients, a most important consideration when new equipment is being commissioned and manpower being trained, and the transfer of equipment to the second panel would occur from like conditions (17° face gradient) and operating experiences and thus produce a safer and more efficient start up to Panel No. 2.

The major disadvantages of this method are the increased distances over which, initially, coal and regular materials have to be transported, and since the face would be travelling to the dip, any water present could affect the area ahead of the face.

The main advantages of the second method are shortest routes for coal and materials and any water is left behind in the waste.

The disadvantages are a steep face gradient on which to start the new system and a change of face conditions on transfer of the equipment from Panel 1 (4°) to Panel 2 (16°/17°).

On balance, we favour the first method whereby the face would commence at the eastern end of the panel, however, other factors may have a bearing on this decision.

The direction of extraction of Panels 2 and 3 is of less immediate importance, though if the east-west route is followed for panel 1, then logically panel 2 should be mined west to east, and panel 3 from east to west (mainly because the more difficult conditions lie at the western end).

(ii) Face Length

The layouts proposed to date, and the locations of the roadways driven, all point to a face length of 550 ft. (168 m). This has been based on specific design and operating criteria, namely, the need to retain access to reserves to the west, and the available mineable coal between the anticline and the syncline.

Longwall faces have varied in length from as little as 180 ft. (55 m) to as long at 750 ft. (229 m). This face length is nearer the average in both the U.K. and the U.S.A. and should be sufficient to both demonstrate all the inherent problems associated with gradients, creep, and control of face line and waste, and to allay criticism that the face length is too short or too long.

(iii) Face Height

This is a function of coal quality and the roof and floor strata conditions.

Critical areas are the amount of immediate roof which caves and its size and hence its ability to fill the waste area quickly and support the overlying roof beds, and the location of weak zones in the seam sections left as floor.

The final selection is a matter for the detailed study and will of course influence equipment specifications.

(iv) Transportation

One of the most important considerations in the efficient operation of an underground mine is the haulage system.

The proposed use of belt conveyors for the rapid and continuous removal of coal from the longwall face to the surface is logical and efficient provided the system is properly designed, installed, maintained and operated.

Similarly, the proposed use of the belt conveyors in specially adapted forms for manriding both in and out of the mines represents an efficient dual usage of mining equipment, and of course is a practice much in use in longwall mines.

No method has yet been specified for the transport of supplies and equipment. It is noticeable in both the 9A and 9G mines that the floor deteriorates in the presence of water where rubber tyred equipment is operated. Additionally, a considerable amount of heavy equipment will have to be transported into and out of the mine. Conditions observed in the 9A and 9G mines do not offer encouragement for trackless vehicles, even if they could handle the weights. It is probable that the detailed study will have to investigate rail, trapped rail or monorail systems as the likely alternatives.

3.3.3 Equipment Tenders

McIntyre Mines has received tenders for the supply of longwall equipment from three manufacturers. These were from:

1) Dowty Mining Equipment Limited - U.K.
2) Eimco Mining Machinery International - U.S.A.
3) Hemscheidt America Corporation - U.S.A.

The tenders have been evaluated and since they were quoted at dates differing by as much as two years, each manufacturer was asked to update their prices and availabilities to June 1982 levels.

Since the tenders are not quoting identical types or lists of equipment, we have given in Table 3-1 a comparison of the major items quoted. In addition, we would make the following comments:

1. Dowty

The original quotation was submitted in September 1981. Dowty had received a copy of the AMCL geotechnical report of July 1981 which discussed probable roof and floor problems.

Dowty addressed both the roof and floor problems and the gradient effects likely to be encountered in the No. 4 seam in the 9G mine.

Dowty have offered a number of alternative equipment specifications including the Anderson Strathclyde or BJD shearers. At this stage of the proposal, it is not possible to determine the exact specification required. The equipment offered does, however, appear to be acceptable with the exception of the face AFC and stage loader. The stated carrying capacities are optimistic in that use is made of lump coal as a transporting medium to enhance the effective cross section of the conveyor. This fact and the major factors to be borne in mind in determining the equipment specifications are discussed in Part 4.3.

2. Eimco

The original quotation was submitted in March 1982 by Eimco representing Mitsui Miike of Japan. The quotation was submitted following a site visit to the mine. The quotation does not identify the mine or seam for which it is offered although the details fit the No. 4 or No. 10 seams. No consideration has been given in the proposal to the potential floor conditions and possible caving problems. No attempts have been made to calculate roof loadings and the capacity of support offered (400T) is not adequate, particularly bearing in mind the previous experience at the mine. No meaningful alternatives were offered.

3. Hemscheidt

The original quotation was submitted in April 1980 by Hemscheidt who included Eickhoff shearer equipment. It appears to have been directed at operations in the No. 10 seam in No. 2 mine. A site visit was made fifteen months after the proposal was submitted, but no changes were made to the original proposal even though the 9G mine was becoming the focus of attention.

Some consideration was given to roof and floor problems in the No. 10 seam in 2 mine, and the proposal contains a lengthy dissertation on the merits of the different types of support available. The type of equipment proposed generally appears to be suitable for the McIntyre conditions, with the following exceptions:

1. The proposal to use a 37.4" (0.95 m) depth of cut seems unwise as this will effectively increase the size, and hence weight, of the roof strata block which would have to be supported by the shields.

2. The supports quoted are too low in operating range for the No. 4 seam.

3. The face AFC and the stage loader capacities are insufficient to meet the peak tonnages expected from the shearer at the cutting speeds quoted.

4. No quotation is provided for the main gate belt conveyor.

It is obvious from the comments made above, and from the comparisons given in Table 3-1, that considerable differences exist in the equiment offered, the data on which equipment types have been selected and the capabilities of the items when matched as a system.

The capital costs, spares recommendations and financial terms vary substantially, but any direct financial comparison is meaningless until all the potential suppliers quote against the same mining specification and conditions.

	DOWTY		HEMSCHEIDT	EIMCO
SHEARER	ANDERSON STRATHCLYDE AM 500 D.E.R.D.S. ALTERNATIVE: BRITISH JEFFREY DIAMOND B58		EICKHOFF EDW 300L D.E.R.D.S.	EIMCO MITSUI MCLE 250/300 - DR 6068 D.E.R.D.S
SUITABLE FOR:	AM 500	B58		
POWERED COWLS	●	●	●	
CHAINLESS HAULAGE	●	●	●	●
LUMPBREAKER	●	●		●
RADIO CONTROL	●	●	●	●
AUTOMATIC LOAD CONTROL	●	●	●	●
BRAKE	●	●	●	●
2 SPEED CUTTING HEAD	●			●
DUST SUPPRESSION	●	●	●	●
AUTO STEERING				●
PRE START WARNING	●	●	●	
ROOF SUPPORTS	600 TONNE 4 LEG CHOCK SHIELD		G 320-16 5/38 2 LEG SHIELD	MK3P - FSC 40 4 LEG SHIELD
LEGS - SINGLE TELESCOPIC				●
DOUBLE TELESCOPIC	●		●	●
ANTI SLEWING DEVICE	●			●
ANTI CREEP	●			
ANTI TOPPLE	●			●
POWER PACK	●		●	●
PIPING	●		●	●
ARMOURED FACE CONVEYOR	1) 864mm 22mm TWIN OUTBOARD 1360 TONS/h (WITHDRAWN) 2) 970mm 26mm TWIN OUTBOARD 1360 TONS/h		TWIN INBOARD DMKF - 4-2X(30-108) 700 SHORT TONS/h	TWIN INBOARD 26mm 800 mm PAN LINE 1000 TONS/h
	1)	2)		
RAMP PLATES	●	●	●	●
BACK SHEETS (CHAINLESS HAULAGE)	●	●	●	●
TAIL GATE DRIVE	●	●	●	●
SIDE DISCHARGE				●
BOX SECTION (PAN CROSS SECTION)				●
SIGMA SECTION (PAN CROSS SECTION)	●	●	●	
CABLE HANDLER	●	●	●	
CHAIN TENSIONER	●	●	●	
CLOSED BOTTOM	●	●		
POWER	2 x 187 kW	2 x 224kW	2 x 224 kW	2 x 150kW
STAGELOADER	1) 864mm 22mm TWIN OUTBOARD 1360 TONS/h 2) 970mm 26mm TWIN OUTBOARD 1360 TONS/h		SINGLE STRAND EKF - 3 - (30-108) 700 TONS/h	TWIN OUTBOARD 22 mm 1000 TONS/h
	1)	2)		
CRUSHER	●	●	●	●
BELT RETURN END	●	●	●	●
TENSIONABLE RETURN END			●	
POWER	82 kW	82 kW	1 x 92 kW	1 x 75 kW
PANTECHNICIAN				●
ELECTRICAL	COMPLETE SET OF LONGWALL ELECTRICS		COMPLETE ELECTRICS FOR LONGWALL	N/A LOCAL PROCUREMENT
FACE LIGHTING	●		●	
COMMUNICATION SYSTEM	●		●	
CABLES	●		●	
MOTORS	●		●	
METHANE MONITORS			●	
HEADING SUPPORTS	S.M.R.E. BAR FOREPOLE		SINGLE PROPS	1) 4LEG SHIELD 2M/S 1T/S 2) 4 LEG SHIELD 2M/S 1T/S 3) 4LEG SHIELD 1M/S 2T/S 4) 4 LEG SHIELD 1M/S 2T/S + SINGLE PROPS
CONVEYOR BELT	150 SL			
LOOP TAKE UP	●			
STRUCTURE	●			
BELT REELING DEVICE	●			

● INDICATES INCLUDED IN QUOTATION

TABLE 3-1

McINTYRE MINE

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LONGWALL DEMONSTRATION PROJECT

EQUIPMENT COMPARISONS

One of the first tasks for the detailed engineering study must be to re-issue invitations to tender against identical specifications, and also to insist that technical and mining representatives from each supplier should visit the potential mine site. The inquiries should be sent to all suppliers who have equipment operating in similar conditions.

The more important parameters which should be borne in mind in developing the revised bid specification are discussed in Section 4.3.

3.4 DETERMINATION OF ROOF STRATA CAVABILITY

3.4.1 General

One of the critical factors affecting the operation of a longwall face is the ease or difficulty with which the immediate strata in the roof above the mining horizon will cave or collapse to fill the void left by the removal of the coal.

This cavability is determined by many factors, of which the most important are:

1) Nature of the immediate roof within two times and five times the seam height.

2) The type and size of powered support used on the face.

3) The bearing capacity of the mining floor.

3.4.2 Roof Strata

The general strata above the No. 4 seam has been described in Section 3.2.1. At the time of this appraisal, no geotechnical information was available from McIntyre for the roof strata, and although an investigative program had been initiated, the results will not be available in time for consideration in this report.

Our preliminary assessment of the cavability of the strata is therefore based on the evidence seen during the mine visits to the 9 surface and 9A and 9G underground mines.

The visits to the 9G and 9 mines gave evidence of the fracture patterns in the roof. The fractures or joints were generally at right angles to the strike with spacings varying from 1' to 6' (0.3 to 6.0 m). These vertical joints generally ran between 15° and 17° off the line of the proposed Panel 1 face (face bearing 40°, joints 55°).

In the 9A mine No. 4 seam, caving was observed in two areas being depillared (Plate 3-2). In the 1 West area, a section of length similar to that proposed for the longwall Panel 1 face was being caved. This demonstrated that the shales, siltstones and mudstones of the immediate roof were caving in two stages. Firstly, the immediate 4'-6' (1.2-1.8 m) was caving immediately in a blocky manner with maximum block sizes of 3' x 3' x 6' (0.9 x 0.9 x 1.8 m). This was followed by the remaining 10'-20' (3.1-6.1 m) of siltstones which caved up to the first of the sandstone beds. The timing of this second cave was variable from twelve hours to two days. The failures of the caved rock in this area were observed to be twofold, along the fracture planes, and where fractures were not evident, in tension parallel to the break lines formed by the pillars and breaker props.

It must be remembered that the strata caving as seen was affected by factors which would not be present on a longwall face. These were:

(i) The first 6' (1.8 m) of the roof in the roadways was bolted and meshed together, which would reduce the tendency to cave.

(ii) The breaking off line was formed by coal pillars and wooden breaker props and did not simulate the line which would be formed by the hydraulic supports on the longwall face in either resistance or alignment (see Plate 3-2).

(iii) Inevitably in depillaring operations, small pillars of coal are left behind, which further hinders the caving process.

As far as could be ascertained the caved material was beginning to support the major roof strata some 50'-60' (15-18 m) behind the caving line. In the depillaring operations, floor coal is also taken resulting in a probable seam recovery of between 50% and 60%. The caved material was thus having to fill this void.

On the visual evidence, we therefore do not see any major problems with the caving of the roof strata as long as this is composed of the shales, mudstones, and siltstones, and that the seam extraction height does not exceed 10'-12' (3.1-3.6 m) in

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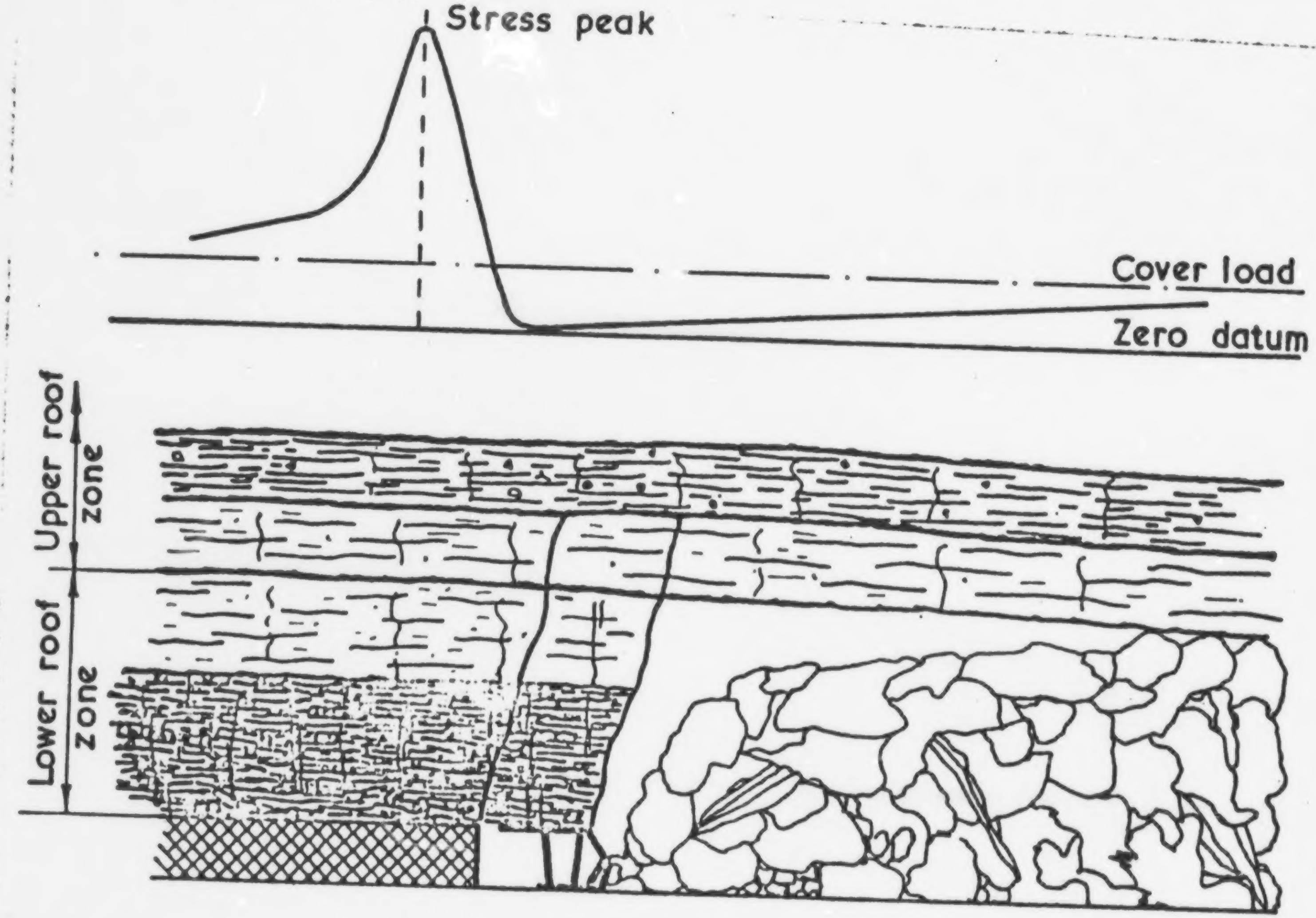
Stress peak
Cover load
Zero datum
Upper roof zone
Lower roof zone

PLATE 3-7

McINTYRE MINE

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LONGWALL DEMONSTRATION PROJECT

LONGWALL FACE STRATA

order that the caved waste fills the void created by mining to provide early support to the major roof beds above the caved area.

However, there is a potential area of concern in the Western end of panel #1. The core logs for borehole C81-23 indicate sandstone to within 18" (0.5m) of the seam roof, whereas the density and gamma logs suggest siltstones and thin sandstones, which would cave easier. This conflict requires further investigation.

If the sandstone beds approach the seam roof - then a different scenario may emerge. Some sandstones have poor or slow caving characteristics, thus there would be less broken rock to provide support to the upper beds, (Plate 3-7), thus all the weight of this strata would act on the face supports causing excessive loading and convergence.

It is therefore essential that the geotechnical program due to be undertaken by McIntyre includes a section for further investigation of the location of the sandstones. This requirement is dealt with in more detail in Section 4.8.

3.4.3 Roof Supports

The type and size of the hydraulic powered roof support will dictate the resistance offered by the support to the roof lowering, and must thus be of a sufficient level to induce the rocks to fail in tension where natural failure along joints is not occurring. This is discussed further in Section 3.5.

3.4.4 Bearing Capacity of the Floor

The mining foor has to be of sufficient strength to support and accept the loads transferred to it by the powered supports, in order to allow those supports to operate in the proper manner. This is discussed further in Section 3.6.

3.4.5 Summary

We are of the opinion that where the immediate roof is composed of shales, siltstones and mudstones, it should be cavable in a longwall mining operation using properly designed and specified powered supports which are operating on a floor of adequate bearing capacity.

The location of the main sandstone beds should be determined during the drivage of the panel roadways and its physical characteristics (strength, joint patterns etc.) determined by core drilling during that drivage.

3.5 POWERED SUPPORTS- OUTLINE SPECIFICATION

3.5.1 General

The function of the powered support is to provide immediate support to the roof (and in thick seams, to the upper part of the coal face) along the longwall face; to provide a line of resistance along which the immediate roof can be induced to cave naturally; to control the lowering of the roof; to prevent the caved rock from flushing into the working area; to transmit the roof and strata loads to the floor, and to act as an anchor for the advancement of the face conveyor.

The selection of a powered support is very much a site specific decision, and requires considerable knowledge of the site conditions. It is obvious from consideration of the previous longwall experiences, and the gradients involved that heavy duty supports will be required. Most supports of this class are of the 'Shield' type, the configuration of which has a mechanical pantograph or lemniscate linkage between the roof canopy and the support base.

This enables a near constant relationship to be maintained between the canopy and the base; and helps to resist lateral forces caused by any relative horizontal displacement of the roof and floor especially on gradient work. The shield also forms a comprehensive cover for the working area from the caved rock.

3.5.2 Support Load Capacity

The method usually used to determine the load carrying capacity of powered support assumes that the chock shield has to support the block of roof immediately above the working face (lower zone). The size and shape of this block is very much site specific. It is this block which should cave behind the supports and ultimately provide support to upper zone strata (Plate 3-7).

Plate 3-8 illustrates the theoretical block and the calculations used to determine the support capacity.

The visual evidence, from the caved zone in the depillaring section in 9A mine, is that the caving line CD is likely to be stepped and extend further into the waste area than is shown in this sketch. Plate 3-9 shows the probable form of this caving

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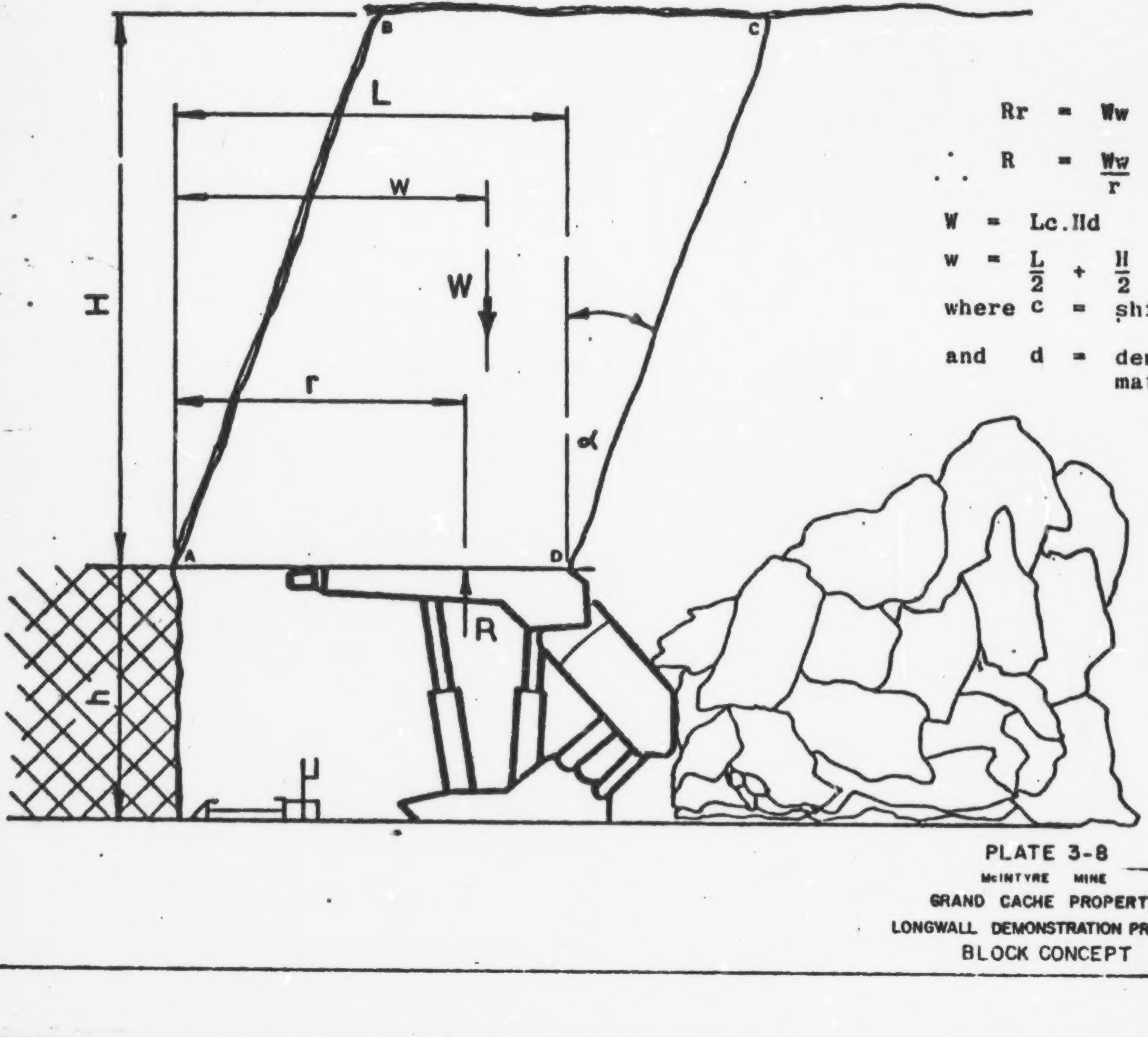

$$Rr = Ww$$

$$\therefore \quad R = \frac{Ww}{r}$$

$$W = Lc.Hd$$

$$w = \frac{L}{2} + \frac{H}{2} \tan \alpha$$

where c = shield cent

and d = density of material

PLATE 3-8

McINTYRE MINE

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LONGWALL DEMONSTRATION PROJECT

BLOCK CONCEPT

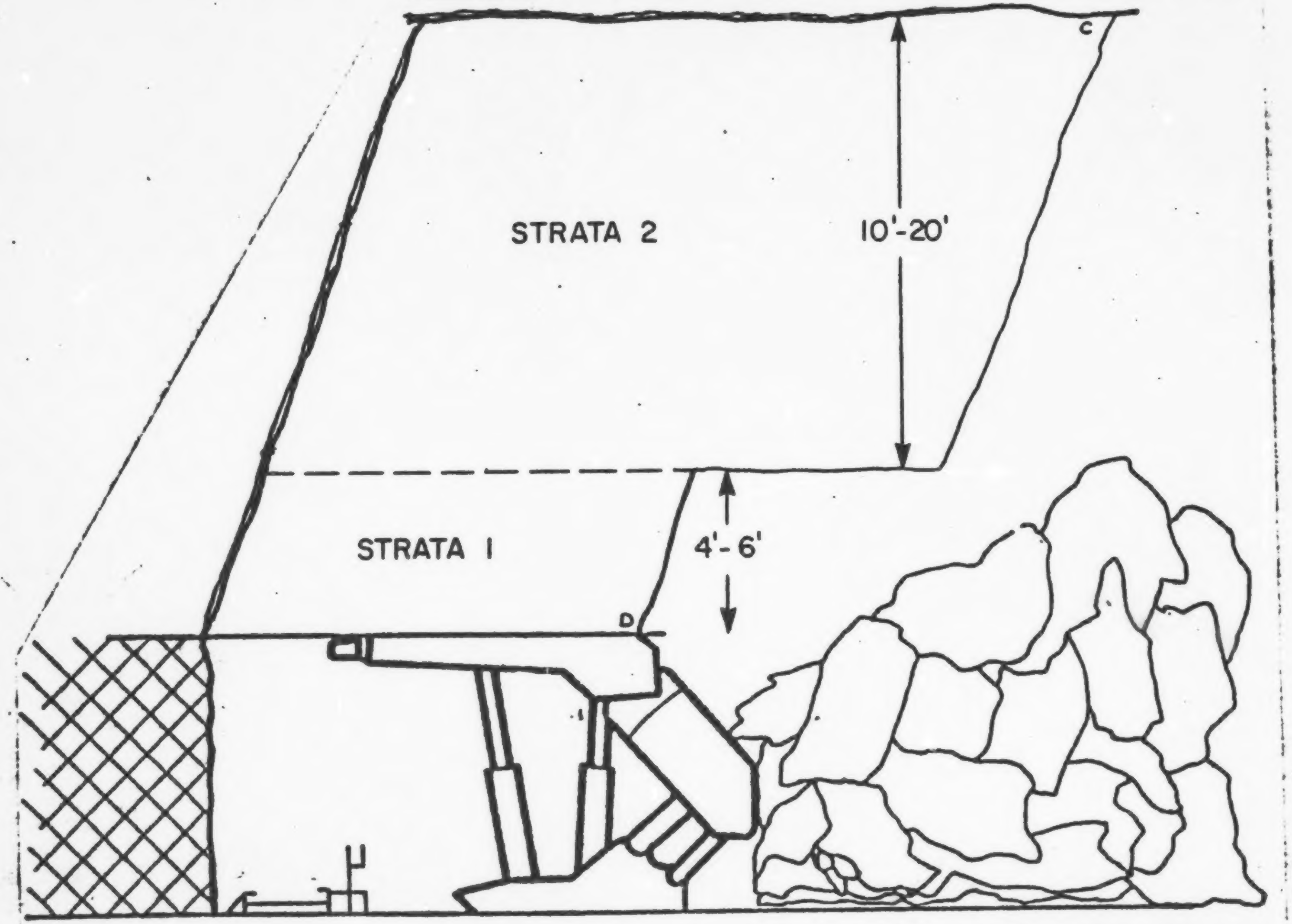
C
STRATA 2
10'-20'
STRATA 1
4'-6'
D

PLATE 3-9

McINTYRE MINE

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LONGWALL DEMONSTRATION PROJECT

PROBABLE CAVE SECTION

line. This should be determined more accurately, in both the 1 west and 2 west depillaring areas in the 9A mine, and the calculations then carried out to determine the actual support rating.

We do not consider the data collected on a single visit to the site sufficient to form the basis of the support specification calculation. No historical data was available from McIntyre.

The only supplier who addressed this problem was Dowty. A sample of their calculations are given in Appendix I. We believe that their figures of load capacity are low because the profile of the immediate caved roof is stepped (Plate 3-9) rather than at one slope (Plate 3-8). The 600 tonne load may be sufficient but requires further checking.

The previous experience with longwall supports in 1970 and 1971 indicated that supports with an equivalent rating of 445 tonnes over a support width of 5 ft. (1.5 m) had too low a load carrying capacity.

A careful study of the shape and size of the strata block which will probably have to be supported by the 'shields' is necessary to provide the essential data on which the support specification should be based.

Following the specification of the required load capacity, the distribution of this loading throughout the support canopy and baseplate should be calculated to ensure their design compliance.

3.5.3 Modifications for Gradient Applications

The operation of any longwall face with moderate to steep gradients along the face length introduces a number of specific problems. The most important of these, which affect the support specification, are stability, creep and misalignment. Provision should be made in the design to incorporate the options available from the manufacturers to cope with these problems. In addition it must also be borne in mind that whilst the average gradient expected in panels 1 and 2 is 17°, this will probably be exceeded in isolated areas on the face. If panel 3 is driven to the same western limit as panels 1 and 2, gradients of up to 29° are forecast. It is quite likely that, in order to operate at this steepness, additional modifications may be necessary. If this is the case, and it is decided to mine this section, these should probably be delayed until the supports are overhauled during the transfer from panel 2 to panel 3.

3.5.4 Soft Floor and Water Problems

In view of the potential need to be able to operate on soft floors, the base area of the supports should be as large as possible to keep the floor pressure low, and consideration should be given to fitting hinged toe plates to assist support advance if floor penetration by the supports, or floor heave becomes evident.

3.6 BEARING CAPACITY OF THE FLOOR

The ability of the mining floor to carry the imposed support loads is of as equal importance to the successful operation of a longwall face as the ability of the roof to cave satisfactorily.

The strength of the floor and its ability to carry the loads which will be imposed through the powered supports, is an area of great concern and in our opinion poses a major uncertainty in the assessment of the suitability of the sites for the longwall demonstration unit.

Although the visual evidence of floor deterioration and heave was, during depillaring operations, less in the 9A mine than in the 5 mine (seen on previous visits), there was sufficient present, particularly at the down dip or northern end of the caved areas, to warrant concern. This is more so when the evidence of the shear zones in the coal below the mining floor is taken into account.

The failure of strata under pressure loading, particularly if it includes zones of little or no shear strength, is a particularly complex sequence. It does appear that the load bearing capacity of a floor can be affected by weak zones within a depth equal to the maximum dimension of the base plate transmitting the load. The load bearing strength of the competent beds in the floor will be the determining factor in relation to the effects any weak zones have on the bearing capacity.

At the time this appraisal was made, virtually no data was available regarding the floor characteristics and its behaviour under simulated longwall loadings. Some preliminary plate bearing tests are currently being undertaken by C.M.R.C. at the mine at selected intervals in the lower part of the seam.*

* Tests completed at one location in 9G mine show encouraging results.

However we must emphasize that as this is one of the areas of major concern, a properly designed and instrumented testing schedule must be undertaken prior to the detailed engineering study, and drill cores taken in the lower part of the seam at regular intervals during the development of the panel roadways, to provide details of the floor composition, on which the suitability of the floor for longwall mining can be assessed.

Additionally, since water is known to be present in the No. 4 seam strata, and because floor strengths are greatly reduced in the presence of water, the tests should include measurements of the effects of water both in and on the coal. The presence of water in drill holes should be checked. Due allowance for the effects of water can be made in the assessment of suitability.

On the basis of a standard 4-leg 600 tonne shield with a base plate hearing area of 14.5 sq.ft. (1.4 m^2) the average floor pressure will be approximately 330 psi (49 kg/cm^2). If however the base is fully plated, the pressure reduces to 260 psi (39 kg/cm^2). This is an illustration of one of several steps which should be considered at the detailed engineering stage to reduce the dependence on floor conditions.

In summary, at the date of writing this report, we do not have sufficient data to be able to determine the suitability of the floor for longwall mining operations. The tests currently being undertaken by C.M.R.C. and continued during the panel development should help to clarify the problem.

3.7 SECONDARY SUPPORT

The areas of a longwall face where the support problems are most complex are those at the junctions of the face with the main and tail gate roadways (face ends).

If the mining method eventually adopted is that of retreating the longwall face along pre-driven roadways, and allowing those roadways to cave behind, then the face end support problems are simplified. The standard procedure would be to extend the powered supports across both roadways so that the supports run from roadside coal pillar to roadside coal pillar. Those support units actually located in the roadways (probably three or four at each end of the face) would be specially modified to provide extra support legs to the leading edges of the canopy. This is essential to permit the face conveyor drive units to be moved under adequately supported conditions (Plate 3-10).

In addition, extra support will be required in the mine roadways between the face ends and the forward abutment pressure zone. This zone varies with the depth of cover and for panel 1 could vary from 66' (20 m) to 260' (79 m) from the face end. Dependent on the conditions experienced, such additional support could take the form of hydraulic props, props and girders, or even chockwood supports. The conditions seen in the 9A mine depillaring areas suggest that if they are typical of the forward abutment pressure effects, the use of hydraulic props and light bars may be sufficient.

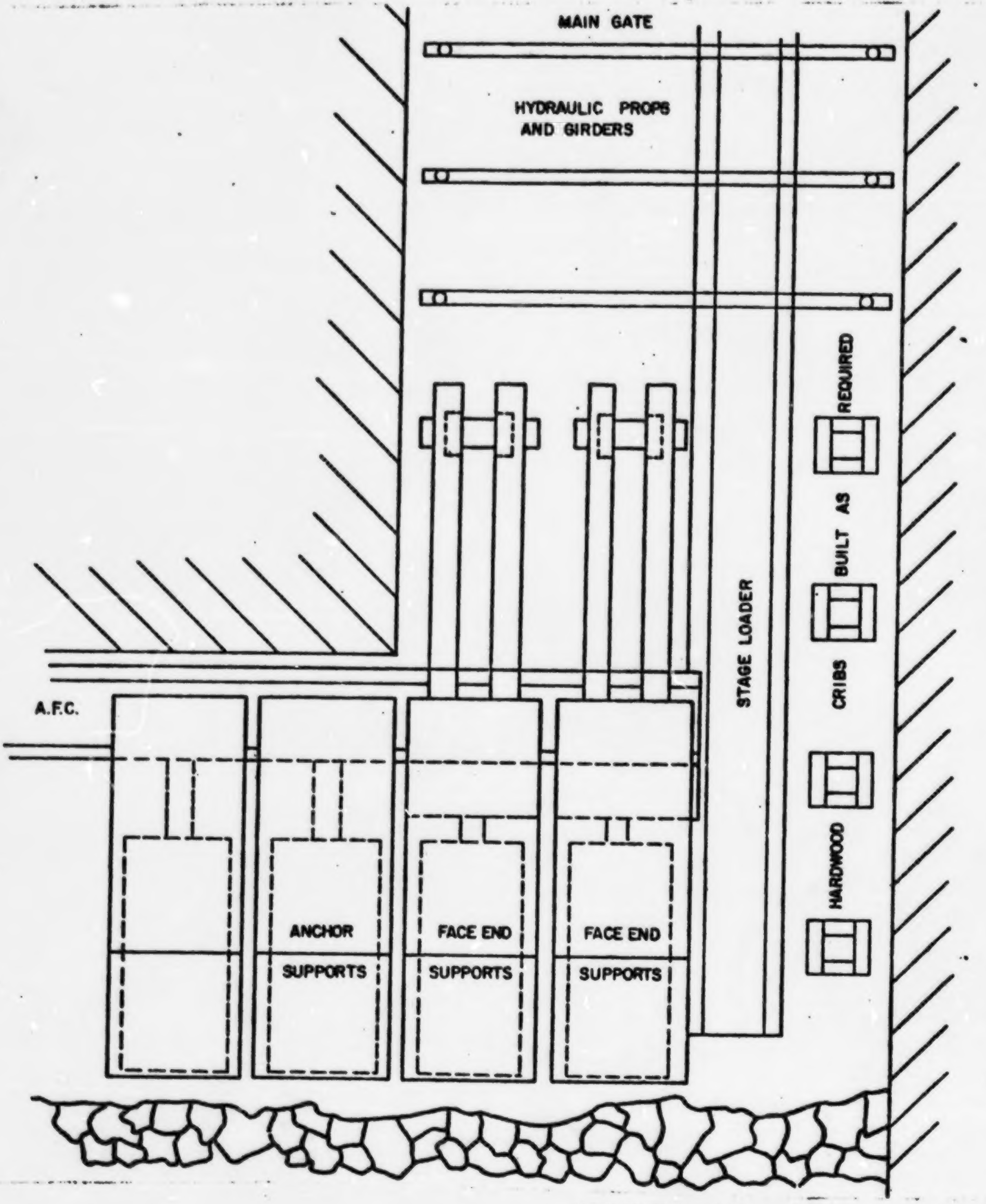

MAIN GATE
HYDRAULIC PROPS AND GIRDERS
STAGE LOADER
HARDWOOD CRIBS BUILT AS REQUIRED
A.F.C.
ANCHOR SUPPORTS
FACE END SUPPORTS
FACE END SUPPORTS

PLATE 3-10

McINTYRE MINE

GRAND CACHE PROPERTY

LONGWALL DEMONSTRATION PROJECT

FACE END SUPPORT RETREATING

PART 4

THE LONGWALL DEMONSTRATION UNIT

4.1 OBJECTIVES

The rationale for undertaking a demonstration of longwall mining techniques in Western Canadian mountain coals has been stated previously in Section 2.1.

Such a demonstration project must have clearly defined objectives. We consider these should be:

(1) to demonstrate that the longwall mining system can be successfully applied to Western Canadian coals and thus make available to the mining industry its desirable advantages of increased safety and productivity and the lower costs which are synonymous with the system;

(2) to provide a data base for interested Western Canadian coal operators to enable them to assess the feasibility of applying this mining technology under their own conditions;

(3) to determine the suitability of the present generation of longwall mining equipment for use in mountain coalfield conditions and to determine such modifications as may be deemed desirable;

(4) to measure and collate data to better determine the behaviour of the mining strata, and thus improve the design criteria for longwall faces;

(5) to make available for recovery, reserves which cannot be mined by conventional room and pillar techniques, or otherwise economically recovered because of gradient limitations;

(6) to demonstrate mining methods whereby the ability of Western Canadian coals to compete in world markets can be improved;

(7) to encourage the development of mining machinery manufacture in Canada;

(8) to provide a basis of performance and conditions against which a future longwall demonstration project in plains coal can be compared;

(9) to simultaneously produce coal economically and provide factual performance and design data; and

(10) to provide facilities to develop new skills for management and labour in the Canadian Coal Mining Industry.

4.2 BASIC DESIGN CONSIDERATIONS FOR A SUCCESSFUL OPERATION

4.2.1 Introduction

It is of vital importance to the western Canadian coal mining industry that the next attempt to operate a longwall mining system is a success.

In order to enhance the success, it is essential that a full and detailed engineering and feasibility study be undertaken to ensure that the mining conditions for the first panel and the equipment specified are the most favourable and suitable.

We have therefore highlighted below the major items which should be considered in the course of the engineering study.

4.2.2 Steep Seam Experience

There are no longwall mining systems in Canada operating in steep seam conditions (greater than 10°). Since the proposed sites for the longwall demonstration project contain areas with gradients exceeding 10°, it is essential that steep seam operating experience in depth is made available to the engineering and operational teams at all levels. This could be achieved as follows:

1. By the provision of expertise from external sources from engineers who have experience of steep seam workings and of longwall operations in steep conditions, for both the study and operational phases.
2. By seconding selected engineers from the design/engineering team to mines (probably in Europe) to study operating steep seam longwall systems.
3. By seconding management, supervisory and face operatives to such operating mines to gain practical experience of current steep seam longwall operations.
4. By utilizing the experience and advice of the many equipment suppliers who have equipment operating in conditions similar to those which will be expected at Grande Cache.
5. By recruiting, if necessary, staff and operatives with relevant steep seam longwall experience.

4.2.3 Most Favourable Mining Conditions

Consideration should be given to providing the most favourable mining conditions possible for the first longwall panel. This consideration could include:

1. Panel Orientation

   The first panel could be aligned relative to the geological structure to keep the gradients to a minimum for as great a distance as possible (by rotating, say, anticlockwise from the position shown on Plate 3-5), and where possible to enable the face to advance to the rise, thus ensuring that any water is left 'behind' the face.

2. **Mining Height**

   The seam height to be mined in the first panel could be reduced from the projected 10' (3.1 m) to a figure in the region of 8' (2.45 m). This would have the effect of placing the operations in the mainstream of the present technology rather than closer to general limits, but would also offer the potential to improve the floor conditions (if further investigation shows the floor to be a problem) by leaving stronger coal as floor.

3. **Face Length**

   Whilst the proposed face lenghth of 550'. (168 m) is 'average', consideration could be given to a shorter face length - say 400' - 450' (120 m - 140 m) for the first panel. Such a change would improve communications and safety, reduce capital costs and generally improve operational efficiency due to compactness, but it would reduce recovery, require faster development and require more frequent face end operations. It must also be remembered that face length will increase as the gradient increases.

4. **Development Layout**

   Since the full section of coal is not extracted by either longwall or room and pillar operations, and because of the inherent problems of sealing off old workings in thick seams for the prevention of ventilation leakage and spontaneous combustion, consideration should be given to reducing the number of cross-cuts in the development drivages. This should have the added advantage of strengthening the pillars alongside the longwall face, thus improving roof control.

5. Transportation

   The design should optimize the transport systems for the mine, not only for coal clearance, but also for men, materials and equipment transportation. The opportunity should be taken to examine systems in operating steep seam mines.

4.2.4 Benefits From Previous Longwall Experience

We have briefly discussed in Section 2.4 the problems which arose with the previous longwall attempts. Obviously, this experience will be borne in mind during the design and operational phases. In fact technological advances have already eliminated or reduced some of these problems.

1. Floor Conditions

   Modern supports operate with much lower floor bearing pressures than a decade ago. However floor bearing strengths have still to be fully assessed.

2. Equipment Design and Reliability

   Current generations of equipment for use in steep seam workings are of proven design and reliability and are available to suit the expected conditions at Grande Cache.

3. Support Load Capacities

   Supports with up to 70% greater load capacity than the 1970 supports are now available. Actual requirements will be developed during the engineering study.

4. Continuous Operation

Longwall systems work best when rates of progress are maintained. The system proposed for the trial should consider continuous operation to provide the best possible mining and strata conditions.

5. Adjacent Operations

The operation of a longwall demonstration unit should be the only 'extractive' mining activity carried out in the same area, in order that a proper assessment can be made of the system, without the influence of extraneous operations.

6. Transportation

Reliable systems are now available for the transport of longwall equipment into and through the mine. These should be examined in operation before the final selection is made.

7. Absenteeism

At the time of previous longwall attempt, the township of Grande Cache was not fully developed, and thus residential conditions were not settled. This is no longer the case and absenteeism and high labour turnover should not be a problem to the need to maintain a skilled longwall labour force.

4.3 SUMMARY DESCRIPTION

4.3.1 Basic Longwall System

The basic longwall system can be considered to consist of the following major components:

(i) A coal cutting machine(s), usually a shearer.

(ii) A flexible chain conveyor (AFC) which transports the cut coal along the face; provides a track for the shearer to travel upon; often incorporates the structure which the shearer uses to haul itself along the coal face, and which forms the anchorage against which the powered supports advance themselves.

(iii) Powered hydraulic supports (including an electro/hydraulic power pack) which support the length of the face.

(iv) Modified powered supports for use at the ends of the face.

(v) A chain conveyor or 'stage loader' situated in the main gate roadway which transfers the coal from the face AFC to the main gate belt conveyor.

(vi) A belt conveyor which travels the length of the mining panel, and transports the coal to the main haulage system of the mine (usually conveyors or mine cars and locomotives).

(vii) Electrical equipment to power and control the above equipment.

(viii) Communications and signalling equipment.

(ix) Face lighting systems.

A typical layout for a retreating longwall face is shown in Plate 4-1. The main components have been identified.

It must be appreciated that there are many variations and alternatives possible and indeed necessary to meet the many mining conditions found throughout the world.

We have listed in Section 4.3.5 the main criteria which should be borne in mind in selecting equipment for the longwall demonstration unit.

4.3.2 Typical Operational Cycle

As with most mining systems there are several operational modes related to the timing of the movement of the roof supports after the coal cutting machine has passed that point along the face.

The original practice, which is often called the "conventional" method simply calls for the movement of the roof supports to a position as close as possible to the actual working face immediately the coal cutting machine had passed and the face conveyor advanced. This reduces the width of the immediate roof which has to be supported by the main roof supports. Unfortunately it also limits the area that is available for the work force to travel in or work in.

An alternate is the "One web back" method where the roof supports are moved over to support the newly exposed roof immediately the coal cutting machine has completed cutting the upper part of the mined section, this allows the work crews approximately 24 inches (0.6 m) more room to travel and work in and tends to aid productivity and in some instances working conditions.

There are many good reasons to use either system and only after a full analysis of the potential strata and seam conditions, the production cycle and after selection of the main longwall face equipment, should the final selection be made.

4.3.3 Typical Longwall Manpower Requirements

As stated earlier the final mine design, equipment selection and production schedules will be developed during the feasibility study. As a general indication of what can be expected

MONTREAL ENGINEERING COMPANY, LIMITED

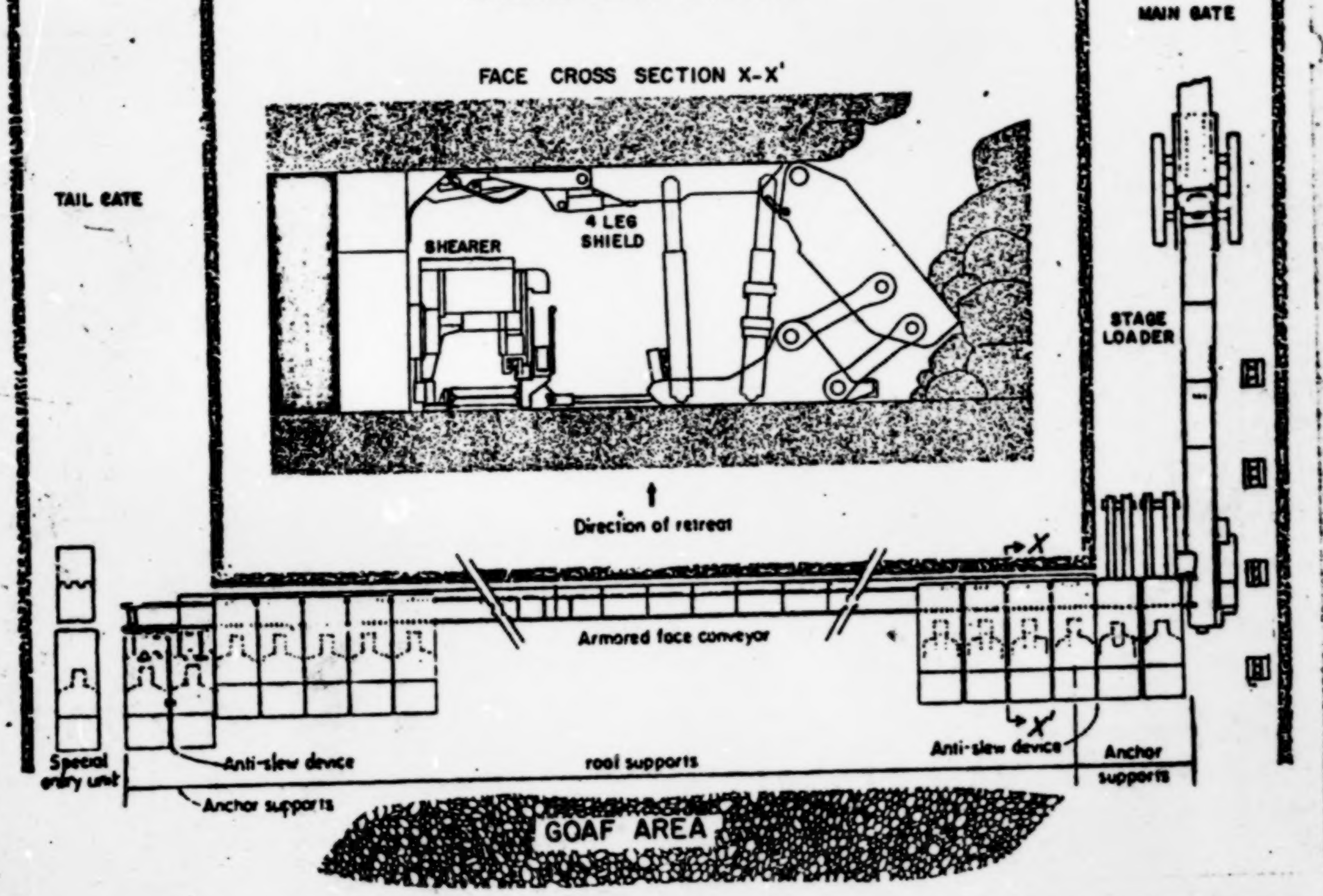
PLATE 4-1

McINTYRE MINE

GRAND CACHE PROPERTY

LONGWALL DEMONSTRATION PROJECT

LONGWALL LAYOUT RETREATING



MAIN GATE
TAIL GATE
FACE CROSS SECTION X-X'
4 LEG SHIELD
SHEARER
STAGE LOADER
Direction of retreat
X
X'
Armored face conveyor
Special entry unit
Anti-slew device
roof supports
Anti-slew device
Anchor supports
Anchor supports
GOAF AREA

McIntyre Mines have presented the following table as a preliminary estimate of the face manpower requirements for a three shifts per day producing face.

Job Description	Per Shift	Per Day
Coal Cutting Machine Operators	2	6
Roof Supports Operators	3	9
General Face end workers	4	12
Mechanic	2	6
Electrician	1	3
Stage Loader Operator	1	3
Longwall Face Supervisors	2	6
	15	45

It is tentatively planned to arrange the working time of the above three working shifts so that a short maintenance shift of a few hours can be worked in between two of these production shifts. This maintenance shift will be manned with a skeleton crew of about four to six people and will carry out such things as conveyor extensions, equipment maintenance etc. The total daily face manpower will thus be between 49 and 51 people. This total excludes all labour and management elsewhere.

These proposed manpower levels are not unduly different from the manpower levels normally associated with such an operation but due to the mining location, seam gradients and conditions may have to be modified slightly to meet specific site related needs after some field experience have been obtained.

4.3.4 Development Systems

The number of roadways required to develop longwall panels and districts is a function of local legislation and general mine layout.

One restraint placed on the development of the proposed longwall district is the need to retain access to future longwall mining areas to the west of the present longwall area. The development of panel #1 thus includes a five heading room and pillar system to the 'south' of panel #1. This incorporates the tail gate for panel #1, three roadways for permanent access to future western areas and the main gate for panel #2. Sufficient roadways will thus be driven in this 'central' block to also provide adequate ventilation during drivage.

Similarily, it will be necessary for safety and ventilation purposes, to drive a minimum of two roadways for the development of the long longwall panels proposed for the retreating system. Plate 3-1 shows this twin roadway system outlined for the various longwall panels.

For the retreating system, the roadways are driven to the limit of the panel. A connecting roadway is then driven at the end of the panel at which extraction will commence, and this will be utilized for the installation of the face equipment.

The mine development and projection plans will be developed during the detailed study and the layouts shown in Plate 3-1 should be treated as conceptual layouts.

The layout finally adopted for any longwall system usually represents a balance between many factors. The following are some of the factors which should be considered in the detailed study.

1. Whilst experience in the 9A mine has shown that a single row of chain pillars is adequate under room and pillar depillaring operations, the ability of such a layout to withstand the abutment pressures under full longwall caving conditions sufficiently to allow one of the two roadways to be used later as an access roadway to the next panel, has yet to be determined.

2. When designing the chain pillars due consideration should be given to the inclination of the seam at the coal face and the tectonic stresses prevalent in the area, particularly due to the close proximity of the synclinal and anticlinal axes.

3. As far as possible, for the sake of an improved distribution of roof stresses and minimum burden on the chain pillars, the panels should be exhausted in a regular sequence beginning from the top of the anticline advancing toward the bottom of the syncline. Conversely consideration should be given to placing the first panel in the most reliable strata with the lowest risk of other types of problems.

   The detailed study should decide which factor has more importance, before mine development proceeds much further.

4. The transportation link for coal between the face and the trunk conveyor system should be as short and simple as possible.

5. It should be borne in mind that the length of the longwall face will increase as the gradient increases (where the panel roadways remain at constant plan width). This

requires the addition of extra roof supports and face conveyor structure at the necessary intervals. (A change from 4° to 17° will require 4 or 5 extra supports). The addition (or removal) of these supports is not an easy manner, but can be simplified if all the supports likely to be affected are to the same specification - i.e. anchor chocks.

6. The demonstration project should start at a point where the first panel can be completed with minimal changes to the geological and other conditions to allow time for the equipment and monitoring systems to become established and proven.

7. The design should provide ample margins of safety and flexibility to deal with potential or unforeseen problems.

8. Because the floor is reported to be very sensitive to water, consequently the longwall face should advance toward a gentle rise in gradient if at all possible and after considering all other factors.

9. Conveyance of coal up steep gradients particularly over 12 degrees should be avoided as much as possible.

10. The detailed design and development of Panels #2 and #3 should as far as possible be based on the experiences gained in Panel #1.

4.3.5 Longwall Equipment

The choice of the proper equipment to best carry out these trials is critical and should be made during the development of the Detailed Engineering Study. The following data is therefore not presented to change that important requirement but to summarize some of the prime items of equipment and their functions.

The longwall coal cutting machine can be one of several types. At this early stage it is suggested that a modern highly productive and powerful double cutting element machine, commonly called a double ended ranging drum shearer should be suitable. This machine should have sufficient power to produce coal at an economic rate, should have built in flexibility with its twin ranging cutting elements to allow various seam thicknesses to be mined without any major equipment modifications, should be fitted with modern dust suppression devices and, as it is well proven, should be reliable if adequately maintained and operated.

When the actual cutting machine is selected it is recommended that the following criteria be considered:

a) Powered cutting element cowls to improve coal loading, to reduce the generation and distribution of coal dust and to provide locations for mounting dust control equipment.

b) The electrical power should be a 1,100 Volts AC supply, the prime electric motor should be water cooled and be complete with audible start up warning devices, thermal overload protection devices and should include dual operating controls at each end of the machine.

c) The speed of the cutting elements (discs or drums) should be of the variable, two speed type to allow evaluations to be made of the cutting action and dust generation with differing pick speeds.

d) A chainless machine haulage system will reduce face hazards and simplify to some extent the face ends equipment eliminating anchorage points for the haulage chain and also minimizing the complications associated with cutting the last few feet, or ends, of the coal face.

e) A coal breaker will reduce the coal size at the machine which not only improves coal transportation on the armoured face conveyor and conveyor belt system but also reduce hazards caused by any lumps of coal rolling down the conveyor systems in the steeply inclined areas of the mine.

f) The cutting element of the cutting machine (disc or drum) should be equipped with pick face flushing and a hollow shaft to assist in the immediate coal face ventilation and to reduce dust problems.

When the armoured face conveyor (AFC) is selected it is suggested that the following criteria be considered:

a) It should be able to carry the peak loading possible from the cutting machine without having to travel at a high speed. The steepest planned gradients should be taken into account when the calculations for this are made with respect to motor horse powers, coal lumps rolling along the face etc.

b) The softness of the coal floor and the steep gradients along the face will tend to put more stress on the conveyor and its ancilliary parts, than normally experienced on level faces, consequently an extra heavy duty type of unit should be selected possibly with a closed bottom pan line.

c) The coal that has been cut by the coal cutting machine will most likely not roll down the coal face, but the coal that falls freely from the face may well roll along the conveyor in the steeper areas. Care should be taken to select all equipment to reduce the effects of this problem and to safeguard the work force.

d) An 1,100 Volt AC electric drive or drives should be standardized to match all the other related equipment and reduce voltage drops.

When the stage loader is selected it is recommended that the following criteria be considered:

a) It should have slightly greater coal carrying capacity than the armoured face conveyor to facilitate adequate coal clearance at the transfer point.

b) All requisite electrical switchgear including the communications system should be mounted on the stageloader, to simplify advance, improve access and cleanliness and to allow standardization of cable lengths.

c) The tail end of the conveyor belt should be an integral part of the stage loader.

The roof support system will most likely be a key factor in determining the outcome of these trials and consequently must be selected with the utmost care. At the moment the data necessary to design or select the supports is not available and must await the completion of a series of tests. It is thought, at this time, that it would be wise to be very conservative in this area and even to overkill slightly in equipment strength, floor and roof pressure requirements, leg yield control requirements etc. Again it will be important to design the equipment so that it can work with ease in the areas where the gradient is steep and the floor is soft.

The electrical system in general should be of the latest F.L.P. and I.S. type with modern fault protection systems built in. It should also be capable, where practical, of including various recording devices to simplify data collection during the trials. A standard voltage 1,100 volts AC at 60 Hz, should be considered for all relevant parts of the longwall system.

4.4 PROJECT CAPITAL COSTS

4.4.1 Equipment Costs

McIntyre Mines supplied Montreal Engineering with copies of three equipment package quotes. These quotes were not developed around a standard and uniform package and included quite varied ideas.

To update the prices to current levels, the three original tenderers (Dowty, Hemscheidt and Eimco) were asked to requote to common face length of 550' (168 m) and seam height 10' to 14' (3.1 m to 4.3 m). In view of the limited time available, no attempt was made to develop a common specification. The prices quoted covered quite varied equipment specifications and systems, and ranged from $7.5 million to $13.1 million. We would consider a price of between $9 and $10 million as being typical of the normal range of longwall face equipment required. Deliveries varied from seven to twelve months ex works.

The following is a partial list of some of the reputable suppliers of this type of equipment who should be considered for participation in this project, at least initially until more data allows the group to be reduced to a short list of prime suppliers.

- Klockner Becorit/National Mine Services Company
- Westfalia Lunen
- Gullick Dobson
- Joy Mining Machinery
- Dowty Mining Machinery
- Eimco
- Hemscheidt
- Jeffery Dresser
- Fletcher Sutcliffe Wild
- Babcock/Harwood
- Thyssen

It is essential after approaching these companies, and others McIntyre may feel suitable, that detailed data is provided to each supplier so that quotations will be directly comparable to each other, directly applicable to this particular coal seam in this particular mine and specifically state the price and delivery F.O.B. site, in Canadian dollars with any taxes or duty fully paid, and with such items as recommended spare parts to be held on site, installation and training assistance etc. clearly stated.

4.4.2 McIntyre Mines on Site Costs

Besides the capital required to purchase the longwall and other related equipment it is necessary in order to assess the full capital cost, to take into account the 'capitalized' costs incurred developing the work site for these trials.

McIntyre Mines have presented their forecast of these initial capitalized costs which are part of the costs associated with this project. These costs are based on a five days per week, three shifts per day basis and are approximately $8.0 million. We understand that these figures only cover the costs which would be incurred during the initial development phase up to the installation of the longwall face.

It is recommended that a breakdown of these costs be provided at the time the detailed engineering study is being developed in order that a proper assessment can be made of the McIntyre contribution to the project.

4.5 PROJECTED PRODUCTION LEVELS AND OPERATING COSTS

4.5.1 Projected Production Levels

McIntyre Mines have presented data with respect to predicted production levels (1.0 M LTR/YR). This data states that a 5 days per week, 3 shifts per day production schedule will be utilized and that a 7 days per week, 3 shifts per day schedule may be considered later. At this time the only operating schedules being used in Canadian underground coal mines are the former, 5 days per week 3 shifts per day. Many alternate schedules are possible, each one with its advantages and disadvantages. It is considered technically reasonable to try to operate the longwall face as continuously as possible to better control strata pressures. A final choice of an operating schedule can be delayed until nearer the starting date for the longwall itself, but for convenience the 5 days per week schedule is suggested at this time and should be used in any cost calculations.

With the 5 days per week operating schedule and an average seam height of 10 feet. McIntyre suggests that the daily average production will be 4,029 Long tons raw (L.T.R.). It is felt that such a production level is possible in the first longwall panel after the initial training period is completed. It is likely that a build up to full production levels could take between two and six months and we feel that the initial production rate should be assumed to be no greater than approximately one third of the average. It must be understood that during these trials and as part of the contract considerable effort has to be made to evaluate all relevant aspects of the trial. This may well reduce these production figures. Some assessment of this reduction should be developed by CANMET and McIntyre during the detailed study.

Because of the location of these trials, away from any other longwall mines and the fact that the system and the modern equipment will be new to many of the people involved, it is felt that the basic major longwall equipment parts should be assembled on the surface before taking them underground for final installation. This will help the operators, maintenance personnel and everyone else involved with the project to become accustomed to working with this equipment and so reduce underground assembly and maintenance problems and also enhance safety.

4.5.2 Operating Costs

McIntyre Mines have presented operating cost data and estimate that operating costs will be approximately $53 per clean longton in the development year, $24.54 in the first production year and $23.02 in subsequent years through to the completion of Panel #3 (1982 prices).

In general these figures are within the normal ranges for such mining systems while coal is being produced at the proposed full production rates. It is unlikely however that these figures will be achieved as an "average" each year as equipment installation and training of the work force during the initial life of Panel #1 will increase costs per ton considerably. Additionally, costs incurred during the periods when Panels #1, #2 and #3 are being salvaged and the equipment moved will also make the average higher than the above forecast.

It should be noted that when the costs are related to the longwall face production they are confined to the area immediately associated with the face and its panel conveyor belt. No costs are included for the materials supply system, coal transportation from the mine or to the coal preparation plant etc.

4.6 PROJECT SCHEDULE

A development and demonstration project of the magnitude, complexity and importance being considered here almost by necessity has to be designed and organized following an integrated system approach. There are several very sensitive elements in the project which have to be coordinated and scheduled in accordance with a plan designed to optimize the costs and reasonably assure the success of the project. The application of CPM (Critical Path Method of Scheduling and Planning) for generating the coordinated schedules and plans should be strongly considered. Because of the sensitive nature of the project related to any uncertainties in the geological conditions existing at the proposed demonstration site, contingency plans should be developed as a part of the master plan to deal with potential problems. The remoteness of the site from the general population centers and the availability of personnel trained to operate steep longwall systems call for a carefully designed human resource plan with schedules fixed for the training and recruitment where necessary of the required supervisory and labour force. Such a plan should give due consideration to the high turn over rate in coal mining in general and any special conditions particular to this mine.

When in existence, this will probably be the only longwall system operating at the time in Western Canada, therefore, a carefully designed schedule for acquisitioning and controlling the inventory of parts and supplies will be required.

Tentatively, the project may comprise of the following elements each of which should be developed and integrated into the master schedule:

a) Pre-mining data acquisition.

b) Longwall mining system design and equipment specifications development.

c) Expert evaluation and review.

d) Preparation of tender documents and equipment acquisition.

e) Facilities development

f) System installation and commissioning.

g) Learning and development panel 1.

h) Longwall demonstration panel 1.

i) Equipment move from panel 1 to panel 2.

j) Learning and development, panel 2.

k) Longwall demonstration, panel 2.

l) Technical and economic data acquisition.

m) Data analysis and information dissemination.

n) Project final report.

o) Project reviews - to evaluate the progress and directions of the project.

p) Zero base reviews - to determine an end point for the demonstration.

q) Training and orientation.

Normally, the demonstration project should be completed in a period of between four and four and a half years as follows:

Pre-mining data acquisition,	3-6 months
Design and equipment bidding package assembly, equipment acquisition Installation and commissioning	14 months
Training experimentation and generally learning how to operate the system (Building up to full production)	2-6 months
Longwall demonstration and monitoring, panel 1 (Full production)	9-13 months
Equipment move and start-up in panel #2	2-3 months
Longwall demonstration and monitoring, panel 2 (Full Production)	12 months
Data assembly and analysis, information dissemination and reporting	4 months

NOTE: If Panel #3 were included in this trial a further 12-15 months would be necessory to complete the mining phase followed by 2 months to salvage the face and transfer the equipment to the next panel.

4.7 RECOMMENDED WORKING ORGANIZATION

The primary objectives of the project are:

a) Design, develop, and conduct a longwall operational trial in the Grande Cache area.

b) Demonstrate the practical feasibility of a longwall operation in the mountainous regions of Western Canada.

c) Develop and collect information and practical data through suitably monitoring the entire demonstration project to promote and support the further design and application of longwall systems in Western Canada.

A review of available information pertaining to the earlier attempts made to use longwall mining at Grande Cache seems to indicate that some of the main reasons for the failure were unsuitable equipment, mining system design, a conflict of Longwall and Room and Pillar extraction methods in close proximity to the longwall units, limited experience of the operators and supervisory personnel particularly with respect to mountain mining conditions, and pressure for production to meet the market commitments.

The organization which should be put in place for the control of this operation should obviously ensure that the previous problems are eliminated.

The organization for the longwall demonstration project falls into two phases.

(1) Detailed engineering and feasibility study and review.

(2) Acquisition, installation and operation of the longwall equipment for the demonstration project duration, including data collection.

1. Detailed Engineering and Feasibility Study

This should be undertaken by McIntyre Mines staff assisted by such additional expertise as they or CANMET consider necessary, since although the site seems adequate to sustain a longwall operation, it is by no means an easy mining situation, longwall or otherwise, being typical of mountainous mining areas in Western Canada.

During the detailed study, CANMET should develop, in discussion with McIntyre, the methods by which the project data will be measured, collated and disseminated.

Upon completion and its submission to CANMET, the study report should be reviewed by independent mining experts before any decision is made to invest public funds and proceed with the demonstration project. This review should also include an assessment of the equipment specified, and the prices and sources of supply for their compatability to the McIntyre Mining conditions.

2. Demonstration Project

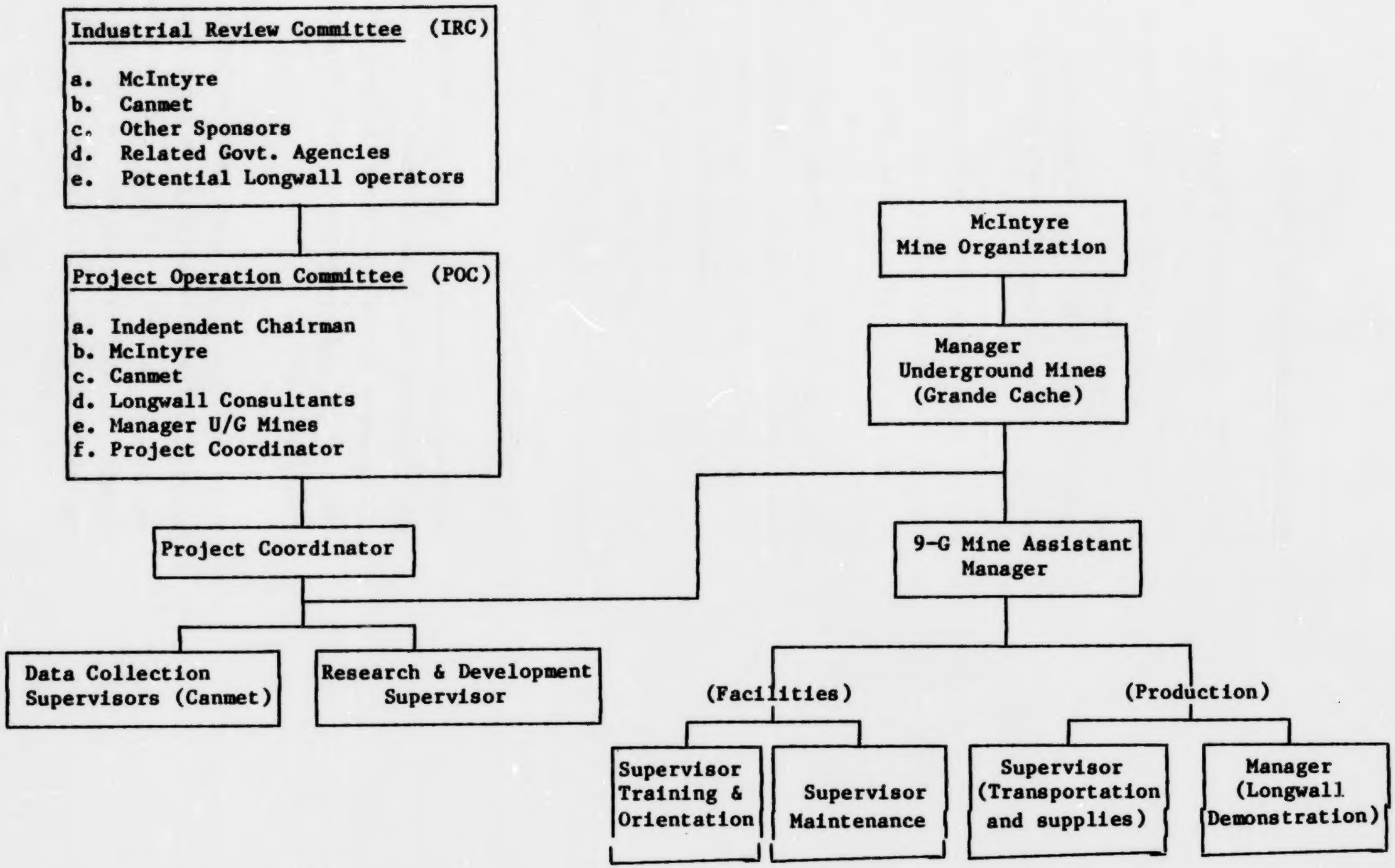
Based on the assumption that the project proceeds after the review of the detailed study, we recommended that an organization of the type shown in Plate 4-2 be adopted for the control and operation of the longwall demonstration project.

While McIntyre Mines must have exclusive authority and responsibility for operating the mine, conversely the data collection and the research and development functions should, as far as possible, be independently conducted by CANMET with the collaboration of the mine operators.

PLATE 4-2

Typical Longwall Demonstration

Project Organization


Industrial Review Committee (IRC)
a. McIntyre
b. Canmet
c. Other Sponsors
d. Related Govt. Agencies
e. Potential Longwall operators
Project Operation Committee (POC)
a. Independent Chairman
b. McIntyre
c. Canmet
d. Longwall Consultants
e. Manager U/G Mines
f. Project Coordinator
Project Coordinator
Data Collection Supervisors (Canmet)
Research & Development Supervisor
McIntyre Mine Organization
Manager Underground Mines (Grande Cache)
9-G Mine Assistant Manager
(Facilities)
(Production)
Supervisor Training & Orientation
Supervisor Maintenance
Supervisor (Transportation and supplies)
Manager (Longwall Demonstration)

The Industrial Review Committee (IRC) which is made up of McIntyre, CANMET and other relevant personnel,should meet at regular intervals to overview the progress of the project and carry ultimate responsibility for it. The project operation committee (POC) which is made up of McIntyre, CANMET and other relevant personnel, should meet probably once a month, to review progress, disseminate information, generally guide the project, and help solve potential problems. In addition, the POC must be available to meet at any time if the Project Coordinator or the Manager Underground Mines feels it necessary.

A strong personnel & training department will be required to ensure the operations maintenance and supervisory personnel have the requisite skills and to promote good inhouse public relations to help keep the objectives of the project in focus at all times.

4.8 CRITICAL KNOWLEDGE GAPS

4.8.1 General

Before the funds are requested for a full field type longwall mining trial much additional information should be obtained.

A major part of this preliminary study called for an evaluation of an engineering study developed by McIntyre Mines. However, due to the timing, such a study was not available, but it has been possible in meetings and discussions with McIntyre personnel to obtain considerable information and thus carryout a reasonable evaluation of their proposals for a longwall demonstration project.

Evaluation of the data collated has highlighted several critical knowledge gaps, and demonstrated that a detailed feasibility study is essential before consideration can be given to any major capital expenditures or major mine development schemes.

4.8.2 Specific Knowledge Gaps

a) Geotechnical - Realistic and comprehensive geotechnical studies covering such items as shear tests in the coal, particularly in the lower section of the coal seam that will have to carry the loading of the face roof support system, in the roof strata to define roof support and caving parameters etc., should be carried out.

In addition, every effort should be made to determine the location of shear zones in the coal and adjacent rocks, any regular cleat formation, fracture patterns, the potential for floor heave and its extent, the bearing capacity of the floor and the cavability of the roof sandstones.

Note: Historically the problems associated with earlier longwall mining attempts at this mine were partially attributed to geotechnical problems and their effects on the system.

b) Geological - Further geological data should be collected during the development of the various roads that will be required. This should include seam gradients, faulting or similar anomalies, seam and strata stratigraphy, including the location and type of sandstone within three times the seam height of the seam roof.

c) Hydrological - Every effort should be made to define the potential for water inflows into the working areas. The mining of this thick coal seam can be expected to be adversely affected in several ways if above normal water quantities are encountered.

d) Mining Conditions - It is important to define, as accurately as possible, the many items that can adversely affect this type of mining method and develop solutions where applicable. The following are the most likely problem items. The rates of methane release, airborne dust generated, spontaneous combustion, floor and roof conditions, the effects of steep gradients on equipment maintenance, production, safety and cost, and time taken to dismantle and salvage one face and refurbish and reinstall the equipment on another face.

e) Longwall Equipment - The detailed engineering study should consider all relevant types of longwall mining equipment that are successfully mining or have mined coal seams similar to the number four seam of McIntyre Mines. This examination should be conducted firstly to select the technically suitable equipment internationally available and secondly to select the most financially attractive package from the technically acceptable short list.

f) Transportation Equipment - It is planned to use conveyor belts for coal transportation. Except for the choice of specific conveyor belt routes and sizes no major problems are forecast in this area as it is well proven technology. It is recommended that a suspended system be considered if floor heave is considered to be a problem.

Materials transportation however has not yet been clearly addressed to the best of our knowledge and as it is extremely important in any mining system, and particularly so when operating a shield type longwall system. It is essential to develop a sound, reliable and easily maintained transportation system. This system should be planned so that it can handle the everyday supplies as well as the major equipment items associated with moving the longwall equipment from one panel to the next. In many mines these systems are fairly easy to develop and operate but at this mine the coal floor may pose some problems and if aggravated by water seepage and steep gradients could make this part of the design more difficult than in more normal mining conditions.

4.9 EXPERIMENTAL WORK AND DATA COLLECTION

Operating parameters should be developed before the project starts and in such a manner that they can be changed in the early stage of trials to respond to the conditions encountered. Experimental data must also be developed and carefully interpreted immediately it is available particularly during the initial start-up period to allow adjustments to be made as necessary. Once the longwall system is functioning satisfactorily extensive and accurate technical, economic and environmental data must be acquired using suitable data collection and monitoring systems. This data, when fully analyzed should provide the basis for the design and development of future longwall systems, including the second and third panels on the demonstration site.

Because a longwall system is very dynamic by nature, electronic data acquisition systems will probably be required to monitor the various parameters on a continuous basis. To simplify installation, maintenance and control, as many of the transducers as possible should be installed as integral parts of the longwall system's basic and normal components. A detailed time study should be undertaken, possibly continuously, to obtain data and assist in coordinating the events of interest within the various operating parameters.

It is recommended that the entire monitoring program be divided into two phases, experimental and demonstration.

4.9.1 Experimental Phase

The data collected in this phase should be utilized primarily for adjusting the system and subsystem operating parameters and operational practices to yield optimum performance. The data thus collected should help to establish the following.

a) Roof pressure distribution profiles along coal face.

b) Influence of any local massive sandstones on the pressure distribution and cavability of the roof supports.

c) Transmittance and distribution of pressure in the mine floor and abutment pillars.

d) Yield rate of face supports.

e) Rate of face advance.

f) Fracture patterns and the rate of their propagation.

g) Behaviour of goafline and caving characteristics.

h) Roof pressure along the entries and on chain pillars.

i) Floor pressures and "heaving" characteristics of the mine floor.

j) Roof stability and deterioration rates in the entries.

k) Water percolation through the mine roof, goaf, and mine floor.

l) Humidity of mine air and any noticeable effects.

m) Nature and amount of power used by various machines.

n) Subsidence.

o) Others that become apparent during the mine design or actual trial.

4.9.2 Demonstration Phase

Extensive amounts of data must be collected in this phase to help the design of future longwall systems in Western Canada. Basically, three types of data are required technical, economic, and environmental.

4.9.2.1 Technical Monitoring

Technical data should be collected, compiled and analyzed to help the development of future longwall mines. The following is a breakdown of some of the prime items that should be monitored:

a) Rates of face advance, maximum, minimum and average.

b) Yield and loading characteristics of the face supports.

c) Optimum face length.

d) Pressure distribution along and across longwall face.

e) Pressure distribution along the head and tail gate entries.

f) Location extent and effect of abuttment pressure zones.

g) Pressures on chain pillars.

h) Optimum entry width and height.

i) Face and entry support systems.

j) Transportation requirements.

k) Energy requirements.

4.9.2.2 Economic Monitoring

Economic data should collected and compiled to help determine and project costs and economic data for use in future longwall systems. Particularly in relation to the various mining parameters, such as:-

a) Optimum production and productivity obtainable.

b) Regular and preventive maintenance requirements.

c) Equipment availability, utilization, and performance.

d) Systems and subsystems optimum performances.

e) Inventory and supplies requirements.

f) Capital and operating costs.

4.9.2.3 Environmental Monitoring

Environmental data should be collected and compiled to help determine the following for future longwall systems:

a) Optimum ventilation requirements to meet quality and quantity standards set by Provincial and/or Federal agencies.

b) Specifications for dust control systems.

c) Illumination requirements on the face and in the entries.

d) Noise control requirements.

e) Others to be determined during the Detailed Engineering Study and during the actual trials.

PART 5

CONCLUSIONS

5.1 EXAMINATION OF POTENTIAL LONGWALL MINING SITES

One aspect of this study was to advise on a suitable location for a longwall mining trial at McIntyre Mines' property near Grande Cache, Alberta. At this time only one block or reserve of coal has been presented for evaluation and consists of a section of the number four seam in the mining area designated as 9.G. As this is the only site offered the study is developed around this single site and no other sites have been viewed or considered.

Observations of the number four coal seam in the field and its associated and adjacent rock strata indicate that a reasonably well defined reserve of folded but not unduly faulted coal lies in one leg of a significant synclinal-anticlinal coal measures structure. This structure has been entered and partially developed by driving a pair of entries from the eastern outcrop and the development of some preliminary panel roadways in the location chosen by McIntyre Mines for the start of their first longwall face.

The coal conditions observed are reasonably regular, for a mountain or foothills coal mine, and roof bolts are adequately supporting the roof at this time. The immediate roof above these roadways is generally shale overlain by sandstones, shales and siltstones. Additional testing of these roof rocks will however be necessary to determine the location of the sandstones in relation to the seam roof and to assess their caving characteristics. The footwall rock is not likely to affect the mining to any extent as due to the difference in mining height, 7 to 14 feet, and the seam thickness, 20 to 22 feet, several feet of coal will remain between the floor of the roadways and longwall face and the true rock floor. This layer of coal between the true rock floor and the working floor is of significant concern as it is upon this material that the main roof supports must build up sufficient resistance to break the roof rocks and maintain the clean break line so necessary to good strata control. Before any field trials of the longwall system can be considered (this does not preclude carrying out a detailed feasibility study) it is essential that tests are carried out to ensure that this lower section of the coal seam can, in the areas to be mined, provided the necessary load bearing capacity.

We consider that, provided these constraints are resolved, the site offered by McIntyre Mines will be adequate for the establishment and operation of a longwall demonstration project, and for the development of a successful longwall mine in mountains/foothills conditions.

The first longwall panel should, at this conceptual stage, be established in the most favorable mining conditions. At this stage of the project, we consider these to be the flattest gradients, however, the detailed engineering study may highlight other factors which could have a bearing on this consideration. For example, it is not possible to utilize the area with the lowest gradients since this is reserved for access to future mining areas.

5.2 EVALUATION OF MCINTYRE ENGINEERING AND FEASIBILITY STUDIES

McIntyre have not yet developed the engineering and feasibility studies in any formal manner. They have, however, made available in both verbal and written form, a considerable amount of their preliminary data. This has been presented as expeditiously as possible, and although the data provided has been generally of a conceptual nature and in some instances dated or related to other seams than No. 4 seam, we are satisfied that we had sufficient data to undertake the appraisal of McIntyre's proposals for a longwall demonstration project.

When developing similar projects in the future, it would be beneficial to establish several phases for the work. These could be:

(1) Conceptual Study.

(2) Appraisal of Conceptual Study.

(3) Detailed Engineering and Feasibility Study.

(4) Review of Detailed Study.

(5) Establishment, operation and monitoring of the project.

5.3 ORGANIZATION AND CONTROL

An organization is required to control the various phases of the project, to ensure that the requirements of both CANMET and McIntyre are satisfied.

Initially, during the detailed engineering and feasibility phase, this should be the simple client/consultant relationship.

The team provided by McIntyre for this study should be made up of engineers with extensive expertise related directly to longwall mining, and with steep seam experience, and others who have extensive first hand experience of underground coal mining in the foothills and mountains of western Canada. To provide direction and control they should be given carefully prepared written directives with schedules, timetables, cost control data and an organizational chart that clearly shows who is responsible for what, when it should be completed etc.

CANMET should provide input, either directly or through consultants, for the measurement and collection of data.

Finally, the detailed engineering and feasibility study, should after its submission to CANMET, be subject to independent review by other mining engineers.

A separate and more formal organization is necessary to operate and monitor the longwall demonstration project, with particular reference to meeting the production requirements of McIntyre, and the data and information needs of CANMET. We believe that a Project Operations Committee should be responsible for the project however, due to regulatory and other legal requirements, it is pointed out that McIntyre Mines will be legally responsible for all mining related parts of the project.

We presume that a contract would be developed between CANMET and McIntyre for the Demonstration Project. This should clearly state the commitment of all parties to the objectives of the project including acknowledgement of the differing and to some extent contradictory requirements of both parties.

An Industrial Review Committee (Plate 4-2) should also be established through which the Project Operations Committee should report progress for dissemination to the industry at large.

5.4 CAVING CHARACTERISTICS OF THE ROOF OF THE #4 SEAM

On the basis of the work carried out to date, it is realistic to assume that the modern shield and/or chock-shield type of roof support will probably be able to support, and cause to cave in a timely manner, the shales and sandstones present in the roof strata of the #4 coal seam at McIntyre Mines #9-G Mine. However, further geological, geotechnical and hydrological work should be carried out to confirm the preliminary assumptions made to date.

5.5 ROOF SUPPORT EVALUATION

Selection of the proper roof supports, together with maintaining a straight cave line and the rapid advance of the longwall face are all essential to the success of this project. Unfortunately the extent of the data available to date and an overall lack of time has precluded the development of roof support specifications. It is possible to state however that modern shield or chock-shield type supports with a support loading in the general range of 600 to 800 tons should be adequate to meet the needs of the conditions at Grande Cache.

The strength of the coal which will form the mining floor is however an area of concern since it has to be sufficient to accept the loads transferred from the roof through the supports.

McIntyre plan to carry out tests on this coal floor to allow calculations to be made and the size of the bases and footplates of the roof supports to be determined. From the information obtained to date and after evaluating the earlier longwall operating informationfrom #2 and #5 mines it would seem possible that the latest roof supports will operate adequately on this soft floor as long as the mine is relatively dry, overly steep gradients are not attempted and the mine is managed and operated in a sound manner.

5.6 SECONDARY SUPPORTS

Modern face end supports can be obtained from many reputable suppliers. It is not realistic with the general lack of data to try to present precise designs for this equipment at this stage.

The present roof bolting method of roadway support is reasonably acceptable and can, if augmented with hydraulic props and bars, etc. at the immediate face ends, be expected to be adequate, particularly where the gradients are not unduly steep and the floor is dry.

5.7 CAPITAL COSTS

Because of the limited information available from McIntyre and the time limitations of the study, a detailed equipment list has not been developed. A basic equipment list is however shown in section 4.3.1 and we assess that capital expenditures for face equipment will be in the range of $10 million ± $2 million dollars.

Delivery of most of this equipment should be quite straightforward as it should be mostly standard equipment with a minimum of modifications. Some of the electrical equipment may have to obtain Canadian and Alberta regulatory approval. This should not take unduly long or be too costly. It is estimated that delivery FOB mine site will take at least twelve months after the placing of a detailed and accurate order.

McIntyre have presented data to show that they will contribute approximately $8.0 million towards the project to develop the basic network of underground roadways. This figure includes a proportion of the mine development capital cost, the capital cost of the panel development equipment and 'capitalized' costs of developing the panel.

5.8 OPERATING COSTS

The data provided by McIntyre indicates that they expect operating costs to be around $24.00 per clean long ton (1982 prices) when the face reaches full production. Our own experience suggests that a figure between $24 and $26 per clean long ton is not unrealistic, if the critical knowledge gaps are closed and conditions found to be suitable. The detailed engineering study should develop these estimates and substantiate or adjust them.

5.9 MINE DESIGN

Considerable work is required in the detailed study to design the mine layout, sequences of extraction and mining heights, equipment selection and methods of strata control and transportation. It is essential that further underground development work be delayed until the design has been finalized.

5.10 SCHEDULES

If the feasibility study engineering package can be negotiated and started without undue delay, it should be completed in the last quarter of 1982. Purchase, delivery and installation of the equipment underground complete with training for the main operators and maintenance people on the surface should take approximately 14 months.

A steady build up to full production levels over the first two to six months can be expected followed by approximately 7 to 11 months of full production (4000 tonnes per day) until completion of the first panel.

It could take approximately 2 to 3 months to refurbish and to move the entire longwall unit to Panel #2 from Panel #1 and after a week or two to regain full production levels it can be expected that full production will be reached and maintained for approximately one year.

5.11 PRODUCTION

The volume of coal in Panel #1 is calculated to be, approximately, one million tons (average thickness 10 feet, panel length 5,000 ft. panel width 550 ft).

McIntyre propose to mine this coal at a uniform rate and complete the extraction in 262 days. This therefore means that an average production rate of 4,036 RLT. per day will have to be maintained during the whole life of the panel.

It is suggested that a slower coal production rate build up, due to the need to acquire up to date longwall skills etc. will be more reasonable. A starting rate of 33 percent of full production during the first month is suggested, increasing to a target of approximately 4,000 RLT per day over two to six months. In addition, the effects of steep gradients on coal production must be evaluated during the feasibility study and could quite well reduce this figure in areas where the seam is very steep.

5.12 GENERAL

A demonstration of longwall mining techniques and equipment in the mountains coals of western Canada can be of immense benefit to the coal mining industry. Such a demonstration must be based on a properly designed and specified system, and operated and monitored in accordance with agreed procedures to provide baseline data which can be used by other mining companies interested in applying the longwall mining techniques to plains, foothills or mountains coal.

PART 6

RECOMMENDATIONS

6.0 RECOMMENDATIONS

In carrying out this appraisal of the preliminary proposals made by McIntyre Mines to CANMET, for the undertaking of a longwall demonstration project at their mine at Grande Cache in Alberta, we wish to make the following recommendations.

1. The longwall mining method offers to prospect of increased safety, productivity and reserves recovery and reduced operating costs. If Western Canada is to contribute to the expected increase in world demand for coal, it is right that the suitability of this method for use in Western Canada is proved.

   We believe that the time is now correct for the demonstration of the longwall mining system, in order that the system is shown to be applicable before the upturn in coal demand arises.

2. Experiences gained in mountain/foothill coals are more readily transferrable to plains coals than vice versa. McIntyre represents the only site currently available for a longwall demonstration project in Alberta.

3. The sites offered by McIntyre Mines have potential for being mined using the longwall system. However, there are certain aspects for which insufficient data are available, the suitability of the proposed sites is thus qualified.

   We recommend that further investigations and tests should be undertaken to finalize the site suitability. These include: floor tests* to determine the load bearing capacity of the mining floor at various locations in the roadways of each panel; core drills in the roof to determine the location of the sandstone beds above the coal seam, boreholes in the floor to locate sheared coal zones.

4. A detailed engineering and feasibility study should be undertaken and the results reviewed by an independent body before any commitment is made to the demonstration project.

   A longwall mine is a reasonably complicated method of producing coal and consequently calls for careful and skilled engineering in a logical and methodical manner. There have been no successful longwall mines in western Canada to date and no successful longwall mines operating in these mining conditions in Canada as a whole. Historically European and United States mining systems have proven less than one hundred percent successful in the foothills and mountains conditions of Alberta and British Columbia, and in almost all cases have had to be modified by people with "local knowledge" to better suit these sometimes trying conditions.

   It is recommended that the expertise of management and engineering personnel who have had extensive experience in the design, development and operation of large Western Canadian coal mines be utilized together with longwall mining experts to carefully design this mine and its associated and related facilities.

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*Tests at the eastern end of Panel 1 have just been completed and give encouraging results.

The engineering group should be brought together to work as a team with one team leader and with very clearly defined goals. It should be responsible for all engineering aspects of the mine and in developing a detailed engineering study should ensure that all geotechnical, geological, hydrological, etc. studies as necessary are completed and adequate to justify the large expenditures called for to purchase the longwall equipment and carry out the trials.

5. Longwall mining equipment has evolved over many years and has become very robust and reliable compared with its predecessors. Equipment that can operate at heights in the range proposed for this project is being successfully used in many advanced mining countries and can be purchased without major modifications from several suppliers.

Because of the importance of selecting compatible equipment and the remoteness of the McIntyre Mine from most of the major component suppliers, it is more than normally important to be extremely careful and methodical in designing the overall package, selecting the components and ensuring that adequate spares, maintenance facilities, etc. are available.

It is essential that each of the major equipment component suppliers, that have equipment working under similar conditions, be invited to send their experts to Canada to view the mining site and conditions and subsequently to present a bid to supply equipment, train personnel, and where applicable, layout maintenance facilities, etc. No single equipment supplier can be expected to provide a comprehesive package that will meet all the needs of these particular mining conditions and in this remote location. It is therefore strongly recommended that an equipment selection team review these critical selection decisions.

As part of the equipment selection process and after short listing major component suppliers, it is recommended that key members of the equipment selection team spend sufficient time viewing this equipment operating in mining conditions as near to those that will be experienced at McIntyre Mines as possible so that the final choice of equipment will be made with up-to-date and first hand knowledge.

6. We recommended that the determination and collection of data from the project should be the responsibility of CANMET, and should be undertaken in collaboration with McIntyre who should expect to provide facilities and assistance for this work.

7. We recommend that a Project Operations Committee be established under an independent chairman, and including representatives of McIntyre, CANMET, and Longwall Mining Engineers to control and monitor the project (excluding the statutory responsibilities which McIntyre have as owner and operator), and to ensure that the requirements of all parties are met.

   We also recommend that an Industrial Review Committee be established to review the progress of the Demonstration Project and disseminate the collected data to interested parties.

8. The estimated life of this project will be approximately four to five years if Panels #1 and #2 are included in the study and possibly a further one to two years if Panel #3 is included. Unfortunately it would be unusual if the same personnel involved today were to be still involved in the closing stages of the project so that every effort should be made to develop an organization that can change its members but still complete the job as planned. It is recommended that careful tabulation of the skills required for every significant aspect of the project and the organization be carried out before the project starts and be strictly adhered to during the life of the project.

   For this reason also, all parties to the contract should acknowledge their commitment to the project for the agreed duration. In doing this, it should be accepted that an initial production build up is necessary, that projected outputs should include allowances for delays due to data collection, and that a demonstration project is not a standard production project.

9. We recommend that in the interests of improving the success of the longwall demonstration, the first working panel should commence on the lesser gradients.

APPENDIX I

TYPICAL ROOF SUPPORT CAPACITY CALCULATIONS

(SOURCE-DOWTY)

5

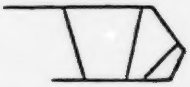
FACTORS INFLUENCING SELECTION OF POWERED SUPPORTS

1. GENERAL

Virtually all longwall powered supports for high duty operation are of the 'shield' type. This is a general terms used to describe supports having a mechanical 'pantograph' linkage between roof canopy and base (referred to as lemniscate linkage) which gives a near constant relationship between canopy and base. resists the lateral forces caused by horizontal displacement of the roof relative to the floor, and forms a comprehensive shield for the working area from the goaf.

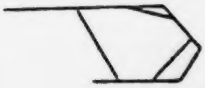
There are a number of configurations of shield, the dominant types being:

i) 4 leg Chock Shield



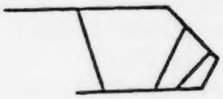
4 legs between base and canopy

ii) 2 leg Shield



2 legs between base and canopy, stabilising ram between rear shield and canopy.

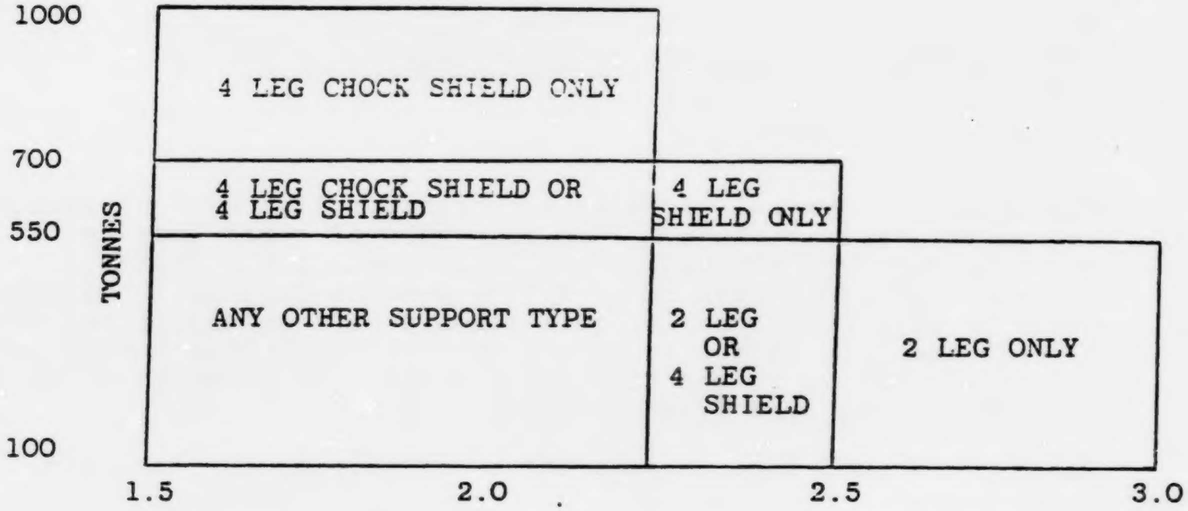
iii) 4 Leg Shield



2 legs between base and canopy
2 legs between base and rear shield.

For many longwall applications any of the support types will give satisfactory operation and selection of support can be simply a matter of personal preference on the part of the engineers concerned. However, each type has specific merits and can be shown to be more appropriate than the alternatives for particular circumstances.

The following diagram is an attempt to summarise the situation.



The diagram indicates the current practical limits of support capabilities in terms of yield tonnage and open to closed height ratio. The boundaries are not absolute, but are realistically set bearing in mind cost and practicality.

It should be recognised that the limits indicated are not the 'norm' for each support design - clearly hydraulic travel costs money and availability of more travel than is required for satisfactory operation is uneconomic.

The support we have specified for the Smoky River application is a 4 leg 600 tonne chock shield designed to operate at 1.5 metre centres giving 400 tonne per metre support. Chock shields of very similar design and rating have been tried and proven in some of the most arduous conditions in the world. Dowty has recently supplied 15 installations (1770 supports) of 4 leg 550 tonne chock shields to the Peoples' Republic of China. All 15 installations are now fully operational with one installation in the Shanxi Province holding their current national output record of 128,000 tonne per month.

2. GEOLOGICAL ASPECT

In selecting the roof supports we have studied carefully the findings in the report prepared by Associated Mining Consultants Limited. From our previous expereince, and considerations a 4 leg chock shield support could best control the strata and enable the shearer and conveyors to return their maximum output from Seams 4 and 10. The configuration of the support would also enable the operators to travel between the legs thereby reducing the risk of coal falling on to the operators. This is of significant benefit when steep seam is to be encountered.

The report by Associated Mining Consultants Limited points out that No. 4 Seam poses a special problem requiring particular attention. Since it is intended to extract the top 12 ft. from a seam thickness of greater than 20 ft., this leaves a sub-

substantial layer of coal below the longwall system. The success of a longwall operation will depend on the competence of this floor for equipment stability.

The upper coal and beds of shaley coal have a compressive strength of approximately 1000 p.s.i. At this figure an installation of heavy duty equipment will not encounter problems of mobility. However, the Associated Mining Consultants' data suggests that the lower section of seam includes shaley coal 15 ft. below the roof with very soft, friable coal near the base in the bottom 6 - 8 ft. of the seam. From our own observations and discussions with mine officials, it appears that this layer of inferior coal (Black Jack) when saturated will not be able to bear loads of any significance. Clearly the exact location of Black Jack will need to be established in order to guaranteee the success of longwalling.

We understand that Black Jack is normally present in large areas and that it does not vary in position or thickness rapidly. When a retreat face is headed out at the intended longwall floor level, regular drillings into the floor should be taken as recommended in roadways and the face heading, and the presence of Black Jack logged. If the thickness of the Black Jack is found to be greater than 2 ft. between 9 - 15 ft. from the seam roof, then the panel should not be longwalled. If soft inferior coal is not present in the roadways or face heading then the risks of it being present in the longwall block will be minimal.

3. SUPPORT LOAD REQUIREMENT

A considerable amount of work has been carried out in various parts of the world to determine the relationship between strata behaviour and support thrust, i.e. required support rating. In theory, the required minimum can be estimated by a gradual reduction of support thrust to the point of instability, when the support fails. Clearly this is a very impractical method due to reasons of safety and cost.

We have based our method on an approach adopted by the National Coal Board of the U.K. This makes the assumption on the amount and shape of the roof which must be supported, to calculate the thrust required to keep this shape in a state of equilibrium and is generally refered to as the 'Block Concept'.

The Block Theory

The Block Concept sets out to determine the forces required to support a block of roof rock which would be released if the supports were to be removed. For the purposes of analysis, the assumption is made that the roof comprises two zones, the lower zone which caves into the waste, and the upper zone which, although it may be fractured, remains continuous and gradually lowers compressing the caved material below it. A typical cross section is shown in Sketch 1.1. The lower roof is not continuous and has a free face along the caving line and relies on the supports to give stability. Should the supports be removed, then the caving line will move forward to the face with the caving angle unaltered, consideration need only be given to this free block on the lower roof zone when assessing the minimum required support thrust.

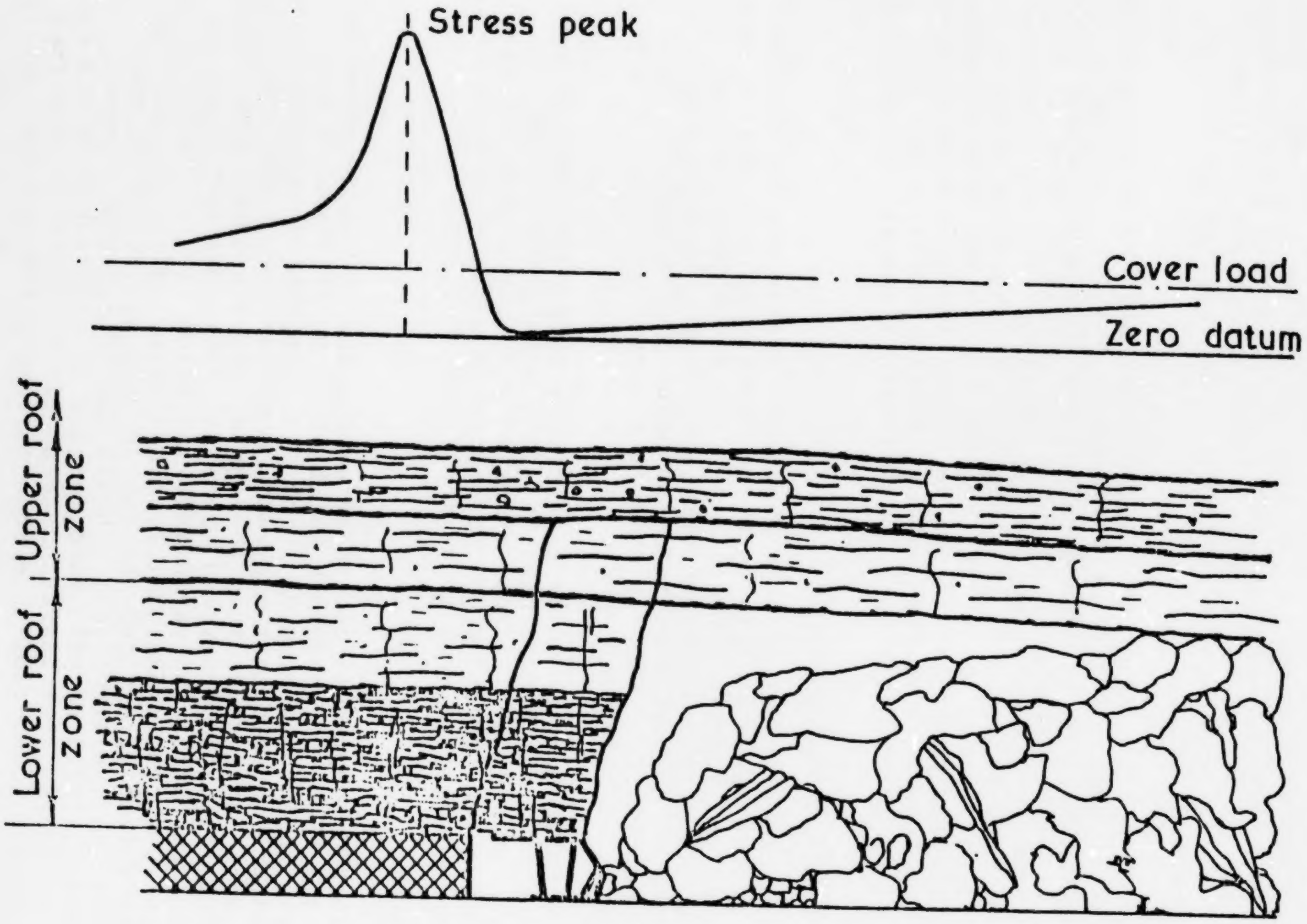

Stress peak
Cover load
Zero datum
Upper roof zone
Lower roof zone

FIG. 1.1

particular angle (α), up to a height (H). This height is often assumed to be simply a function of extracted height (h). In this case we have considered H to be comprised as follows:

Seam 4.	Seam 10.	Seam 11.
Mudstone 2.5 ft.	Siltstone 11.5 ft.	Assumed
Siltstone 20ft.	Siltstone massive 4 ft.	5h
Sandstone 41.5 ft.	Shales 10 ft.	Sandstone 40 ft.
	Sandstone 45 ft.	
64.0 ft. (5h)	70.5 ft. (5h)	

We have assumed caving angles of 30° in shales and siltstone and 35° in sandstone

We then assume that a break is encountered at the face line and the supports must handle the load generated by the load W from the strata block A,B,C,D. This will be the extreme condition (See Fig. 1.2.) Should the roof remain unbroken over the working area, the supports will not have to withstand the full weight if the lower roof zone block, which will have a degree of stability as a cantilever, projects out from the face. This may further assist by the adhesion between the two zones.

In our experience support capacities calculated by this method have never been under capacity.

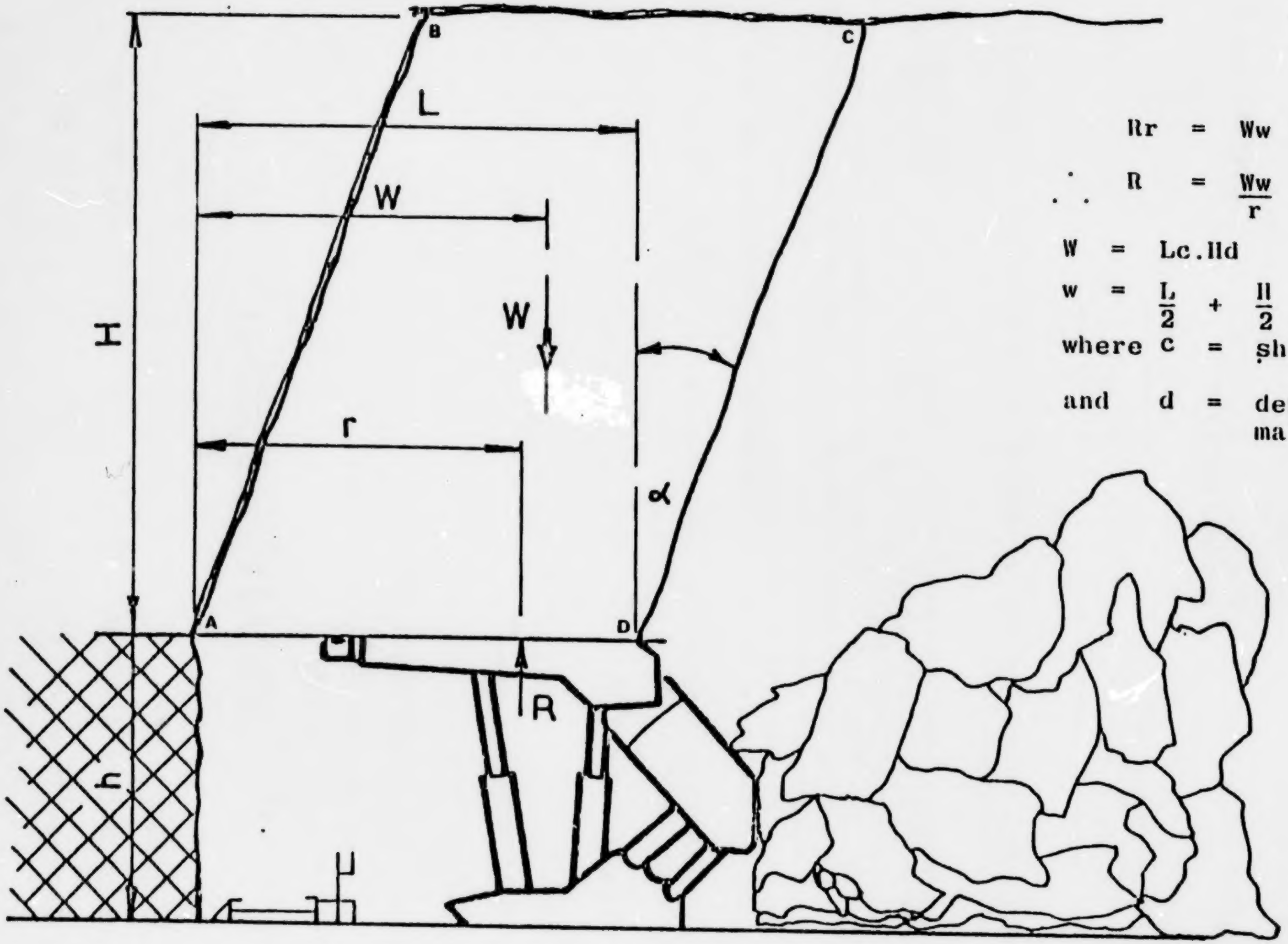
Our calculations give:

No. 4 Seam

Weight of Strata A,B,C,D	254 tonnes
w (distance to c. of g.)	16.86 ft.
Support resistance required	501 tonnes
With length of supported roof 11ft support density required	9.25t/sq. ft.
Factor of safety $\frac{\text{(Actual support density)}}{\text{(Required support density)}}$	1.19

No. 10 Seam

Weight of Strata A,B,C,D	221 tonnes
w (distance to c. of g.)	13.10 ft.
Resistance required	347.31 tonnes
Density required (11ft supported)	6.39 t/sq. ft.
Factor of safety	1.73


B
C
L
w
H
W
r
α
A
D
R
h

$$Rr = Ww$$

$$\therefore \quad R = \frac{Ww}{r}$$

$$W = Lc.Hd$$

$$w = \frac{L}{2} + \frac{H}{2} \tan\alpha$$

where c = shield centres

and d = density of roof material

FIG. 1.2

No. 11 Seam

Weight	198 tonnes
w	20.8 ft.
Resistance required	368 tonnes
Density required (11ft. supported)	6.78 t/sq. ft.
Factor of safety	1.63

4. SUPPORT CHARACTERISTICS

Based on the requirements of No. 4 Seam a yield capacity of 600 tonne per support will ensure that with high pressure set the calculated resistance will be obtained at setting.

The expereince of longwalling in No. 4 seam at Smoky River 10 years ago cannot be ignored. Dowty twin beam 4 leg chock supports at 400 tonne yield capacity on 4' 6" centres would equate to 445 tonne per 5 ft. centres. Our records show that the supports were constantly on yield. Therefore our recommendation of an increase of yield capacity of 35% would appear to be justified by this experience.